APPENDIX G-AQUA5
AQUATIC RESOURCES
EFFECTS OF ALTERNATIVE 2

This appendix provides qualitative analyses of potential effects on aquatic resources with implementation of Alternative 2, relative to the No-Action Alternative. Although the following topical outline is consistent for analysis of each alternative, effects on several issue areas are not anticipated to occur under Alternative 2. From an aquatic resources perspective, there are only a few differences between the No-Action Alternative and Alternative 2. (See Section 3.1, No-Action Alternative, and Section 3.3, Alternative 2, for a detailed description of No-Action Alternative and Alternative 2 conditions.) Oroville Facilities net flow releases and reservoir water surface elevations under Alternative 2 are anticipated to be the same as under the No-Action Alternative. Therefore, no quantitative analysis is required or provided to show potential effects on aquatic resources related to changes in flows below the Thermalito Afterbay Outlet in the lower Feather River or reservoir water surface elevations and the resultant effects on the quantity, quality, or distribution of fish habitat.

Actions included in Alternative 2 that are relevant to the quantitative assessment of effects on aquatic resources, and that are not included in the No-Action Alternative, consist of changes in water temperature management targets at Robinson Riffle and increases in minimum flows in the Low Flow Channel. Under Alternative 2, flows in the Low Flow Channel would increase from 600 cubic feet per second (cfs) under the No-Action Alternative to 800 cfs, and from May 1 through June 15 would increase to either 1,200 cfs or the total project release, whichever is less. These flow and temperature changes are evaluated quantitatively in the subsections below. Additional description and analysis of the flow changes are available in Section 5.4.2.1, Water Quantity Environmental Effects.

Actions included in Alternative 2 that are relevant to the qualitative assessment of the effects on aquatic resources, and that are not included in the No-Action Alternative, consist of improvements to existing side-channel fish habitat, creation of new side-channel habitat, and a Gravel Supplementation and Improvement Program and Large Woody Debris Supplementation and Improvement Program for the lower Feather River. Additionally, Alternative 2 includes installation of fish barrier weirs for the segregation of fall-run and spring-run Chinook salmon spawning, and adaptive management of the Feather River Fish Hatchery. These actions are evaluated qualitatively in the subsections below. A detailed description of the methodology used to analyze potential effects on aquatic resources is provided in Appendix G-AQUA2, Methodology.

G-AQUA5.1 HABITAT COMPONENTS AFFECTED BY THE OROVILLE FACILITIES

G-AQUA5.1.1 Chinook Salmon Spawning Segregation

Actions associated with installation of fish barrier weirs to address the spatial segregation of spring-run Chinook salmon under Alternative 2 are identical to those actions included with implementation of the Proposed Action. (See Section G-AQUA4.1

in Appendix G-AQUA4, Effects of the Proposed Action, for an evaluation of these actions relative to the No-Action Alternative.)

G-AQUA5.1.2 Macroinvertebrate Populations

Macroinvertebrate communities in the lower Feather River would likely benefit from implementation of Alternative 2. The Large Woody Debris Supplementation and Improvement Program included in Alternative 2 would benefit macroinvertebrates by increasing habitat diversity and contributing nutrients. Gravel supplementation and improvement would reduce substrate armoring, improving the quality of macroinvertebrate habitat. The improvement of Moe's Ditch and Hatchery Ditch, as well as the creation of additional side-channel habitat and increased flows in the Low Flow Channel included in Alternative 2, would also increase the quantity and diversity of habitat for aquatic macroinvertebrates.

G-AQUA5.1.3 Woody Debris Recruitment

Actions associated with the Large Woody Debris Supplementation and Improvement Program under Alternative 2 are identical to those actions included with implementation of the Proposed Action. (See Section G-AQUA4.1 in Appendix G-AQUA4, Effects of the Proposed Action, for an evaluation of these actions relative to the No-Action Alternative.)

G-AQUA5.1.4 Gravel Recruitment

Actions associated with the Gravel Supplementation and Improvement Program under Alternative 2 are identical to those actions included with implementation of the Proposed Action. (See Section G-AQUA4.1 in Appendix G-AQUA4, Effects of the Proposed Action, for an evaluation of these actions relative to the No-Action Alternative.)

G-AQUA5.1.5 Channel Complexity

Implementation of Alternative 2 would include enhancement of the existing side-channel habitat in Hatchery Ditch and Moe's Ditch, both located downstream of the Fish Barrier Dam and adjacent to the Feather River Fish Hatchery. Enhancements to these existing side channels could include reforming of the channel for increased water depth and shoreline diversity, placement of boulders and woody debris for cover and velocity diversity, and gravel substrate supplementation. The enhancement of these existing side channels would benefit steelhead and spring-run Chinook salmon primarily by increasing the quantity and quality of spawning and rearing habitat.

Alternative 2 also includes construction of new side-channel habitat to benefit spring-run Chinook salmon and steelhead spawning and juvenile rearing. Construction of the side channels would increase the amount and improve the quality of available habitat for these two ESA-listed species during the important spawning and juvenile rearing life stages that occur in the lower Feather River.

G-AQUA5.1.6 Water Quality Criteria for Aquatic Life

Water quality conditions for aquatic life are not expected to change with implementation of Alternative 2, with the exception of any short-term water quality effects associated with instream construction activities such as the fish barrier weirs, structural modification of Shanghai Bench and Sunset Pumps, enhancement or construction of side-channel habitat, the Large Woody Debris Supplementation and Improvement Program, or the Gravel Supplementation and Improvement Program. See Section 5.4.2.2 for an evaluation of construction-related effects on water quality.

G-AQUA5.2 WARMWATER RESERVOIR FISHERIES

G-AQUA5.2.1 Operations-related Effects

G-AQUA5.2.1.1 Spawning and Initial Rearing

No changes in reservoir water surface elevations, rates of reduction, or surface level fluctuations in Lake Oroville or Thermalito Afterbay are anticipated under Alternative 2, relative to the No-Action Alternative.

G-AQUA5.2.1.2 Fish Interactions

No changes in warmwater fish stocking, habitat improvement programs, or the frequency of sediment wedge exposure affecting reservoir and upstream tributary fish interactions are anticipated under Alternative 2, relative to the No-Action Alternative.

G-AQUA5.2.2 Fisheries Management–related Effects

G-AQUA5.2.2.1 Stocking

No changes in warmwater fish stocking or the habitat enhancement program are anticipated with implementation of Alternative 2.

G-AQUA5.2.2.2 Disease

No changes in the types or rates of warmwater fish diseases are anticipated with implementation of Alternative 2.

G-AQUA5.2.2.3 Recreational Access or Fishing Regulations

Section 5.10.2, Recreation Resources Environmental Effects, forecasts a one-third increase in recreation and angling activities with the No-Action Alternative and an approximately 51 percent increase in recreation and angling under Alternative 2, as compared to the existing condition. This would indicate an expected increase of approximately 18 percent in recreation and angling under Alternative 2, relative to the No-Action Alternative. A 18 percent increase in angling, with no other PM&E measures associated with fisheries, would potentially result in increased sport fish harvest rates and reduced catch sizes and catch rates. Fishing access would be increased under

Alternative 2 with the implementation of several recreation facilities. No changes in regulations for warmwater sport fishing are anticipated with implementation of Alternative 2.

G-AQUA5.2.3 Summary of Potential Effects on Warmwater Reservoir Fisheries

No changes to the quality, quantity, or distribution of warmwater fisheries habitat are anticipated. Increased angler sport harvest rates may adversely affect the quality of the warmwater sport fishery with implementation of Alternative 2.

G-AQUA5.3 COLDWATER RESERVOIR FISHERIES

G-AQUA5.3.1 Operations-related Effects

G-AQUA5.3.1.1 Habitat Availability

The reservoir surface elevations and drawdown rates under Alternative 2 are the same as under the No-Action Alternative. Water temperature targets for the lower Feather River are lower in Alternative 2 than in the No-Action Alternative, therefore release of the coldwater pool is somewhat increased under Alternative 2. As a result of increased coldwater releases, the coldwater pool volume is decreased somewhat in Alternative 2 relative to the No-Action Alternative. (See Section 5.4.2 for additional information on changes in coldwater pool volume.) Coldwater fish habitat is defined by the volume of water that meets both water temperature and DO requirements to support coldwater fish species. Suitable coldwater fish habitat meeting both of these criteria tends to exist in the upper portion of the coldwater pool below the thermocline. Because Alternative 2 is not expected to alter the nature of the thermocline or DO in the reservoir, the effective volume of water meeting the coldwater fish habitat criteria is not expected to change with implementation of Alternative 2.

G-AQUA5.3.1.2 Fish Interactions

No changes in fish stocking or in the frequency of sediment wedge exposure from Lake Oroville water surface elevations are anticipated with implementation of Alternative 2.

G-AQUA5.3.2 Fisheries Management–related Effects

G-AQUA5.3.2.1 Stocking

No changes in coldwater fish stocking are anticipated with implementation of Alternative 2.

G-AQUA5.3.2.2 Disease

No changes in potential exposure to fish diseases is anticipated with implementation of the Alternative 2.

G-AQUA5.3.2.3 Recreational Access or Fishing Regulations

Section 5.10.2, Recreation Resources Environmental Effects, forecasts a one-third increase in recreation and angling activities with the No-Action Alternative and an approximately 51 percent increase in recreation and angling under Alternative 2, as compared to the existing condition. This would indicate an expected increase of approximately 18 percent in recreation and angling under Alternative 2 relative to the No-Action Alternative. A 18 percent increase in angling, with no other PM&E measures associated with fisheries, would potentially result in increased sport fish harvest rates and reduced catch sizes and catch rates. Fishing access would be increased under Alternative 2 with the implementation of several recreation facilities. No changes in regulations for coldwater sport fishing are anticipated with implementation of Alternative 2.

G-AQUA5.3.3 Summary of Potential Effects on Coldwater Reservoir Fisheries

No changes to the quality, quantity, or distribution of coldwater fisheries habitat are anticipated under Alternative 2. Increased angler sport harvest rates may adversely affect the quality of the coldwater sport fishery with implementation of Alternative 2.

G-AQUA5.4 LOWER FEATHER RIVER FISH SPECIES

The overall determination of effects on each species of primary management concern in the lower Feather River with implementation of Alternative 2 incorporates all of the types of effects associated with each PM&E measure included in the alternative for each life stage of the species. Qualitative and quantitative analyses were performed on various potential effects resulting from implementation of Alternative 2 to determine the incremental effects associated with each PM&E measure included in the alternative. The results of the effects analysis of each PM&E measure on each life stage were synthesized to determine the overall effects of the alternative on the species.

G-AQUA5.4.1 Fall-run Chinook Salmon

G-AQUA5.4.1.1 Flow-related Effects

Adult Immigration and Holding

An increased instream flow of 800 cfs in the Low Flow Channel under Alternative 2 could potentially have a beneficial effect on immigrating and holding fall-run Chinook salmon by increasing the lower Feather River stage elevation over potential critical riffles. Although stage increases would be small, shallow riffles could potentially become deeper, reducing the effort required by immigrating adult fall-run Chinook salmon to proceed through shallow riffles. In addition, water depth would be increased, creating additional amounts of suitable holding habitat relative to water depths.

In addition to a base flow of 800 cfs in the Low Flow Channel, from May 1 through June 15 flows could increase to 1,200 cfs. Section 5.4.2.1 provides a detailed description of the circumstances under which flow increases to 1,200 cfs would occur in the Low Flow

Channel. It is unlikely that flow increases from May through June 15 would affect fall-run Chinook salmon adult immigration and holding because the fall-run Chinook salmon adult immigration and holding period in the Feather River extends from July 15 through December 31.

No flow changes relative to the No-Action Alternative are expected in the High Flow Channel with implementation of Alternative 2.

Adult Spawning and Embryo Incubation

Under Alternative 2, flow in the Low Flow Channel would be 800 cfs year-round, except from May 1 through June 15 when the total releases of the Oroville Facilities, up to a maximum of 1,200 cfs, would be released down the Low Flow Channel. Flow fluctuations in the Low Flow Channel could potentially occur under Alternative 2 to meet water temperature objectives prescribed to protect fisheries resources, or through change in total releases occurring below 1,200 cfs during the May 1 through June 15 period.

Increased flow releases to meet water temperature objectives during September could potentially affect fall-run Chinook salmon spawning and embryo incubation by causing redd dewatering, which could occur as flows return to normal after water temperature objectives are met. Because increasing flows to meet water temperature objectives increases river stage, spawning individuals could potentially construct redds in areas that could be dewatered as flows are lowered to normal levels (800 cfs). However, based on data available on stage-discharge relationships of Low Flow Channel salmonid spawning riffles and Chinook salmon redd water depth distribution from the SP-F16 report (see Section G-AQUA1.10 of Appendix G-AQUA1, Affected Environment), the first redds would not be dewatered until there was more than a 0.4-foot change in stage elevation. Water temperature control flow changes are at or less than 200 cfs, and from 800 cfs to 1,000 cfs all of the spawning riffle stage elevations change less than 0.4 feet. This analysis indicates that no redds would be dewatered in water temperature control–related flow changes in the Low Flow Channel.

Evaluation of the Weighted Useable Area (WUA) index generated by the PHABSIM model for the adult spawning life stage of Chinook salmon (spring-run and fall-run) indicated that the maximum amount of spawning area in the Low Flow Channel, given the current channel configuration, would occur at flows around 850 cfs. Figure G-AQUA5.4-1 shows the WUA curve generated by the PHABSIM model for Chinook salmon spawning in the Low Flow Channel.

Flows in the Low Flow Channel during the spawning period for fall-run Chinook salmon would be 600 cfs under the No-Action Alternative, resulting in approximately 91 percent of maximum WUA. Flows in the Low Flow Channel during the spawning period for fall-run Chinook salmon would be 800 cfs under Alternative 2; according to PHABSIM model results, this would result in almost 100 percent of maximum WUA, representing an increase in the quantity of available spawning habitat compared to the No-Action Alternative.

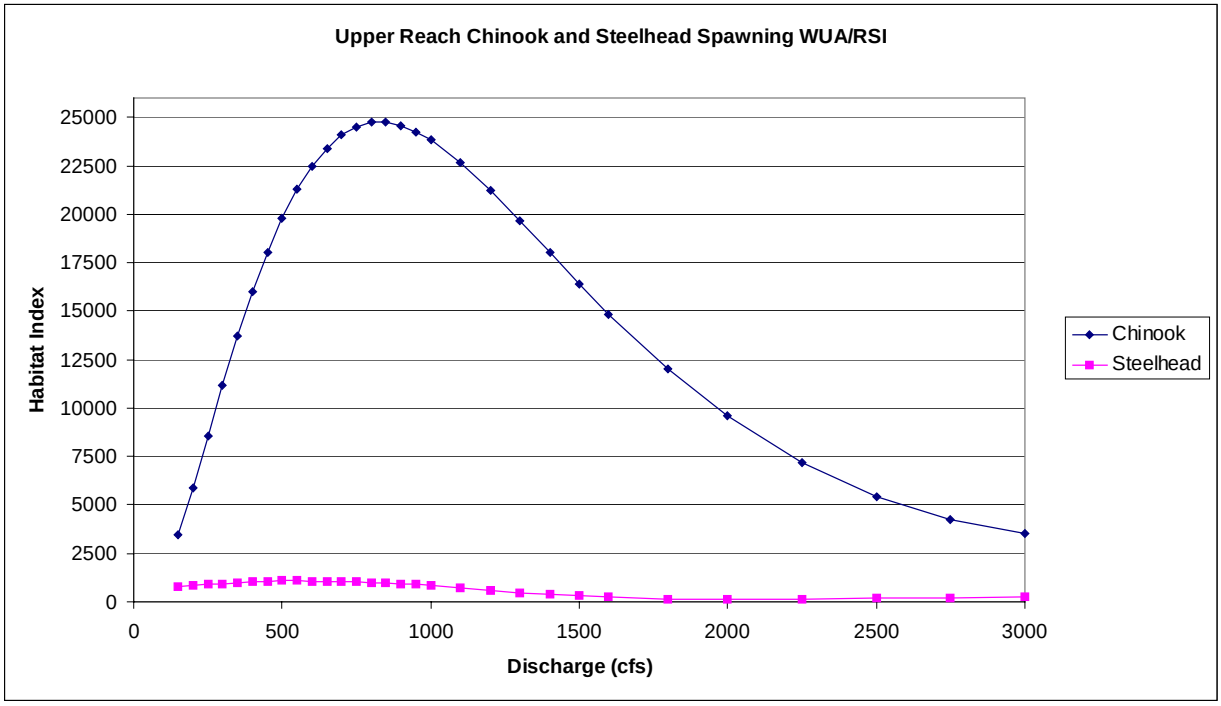

Figure G-AQUA5.4-1. Low Flow Channel WUA curves for steelhead and Chinook salmon.

During extreme drought conditions, total releases from the lower Feather River could be reduced such that releases are no greater than 25 percent of the minimum flow requirement below the Thermalito Afterbay Outlet. The 25 percent reduction in flow below the normal minimum flows amounts to a total flow of 750 cfs below the Thermalito Afterbay Outlet from March through September. The changes in the minimum flow requirements below the Thermalito Afterbay Outlet also could result in reduced flow in the Low Flow Channel. In extreme drought conditions, under Alternative 2, flow in the Low Flow Channel would be 750 cfs at the beginning of the spawning period for fall-run Chinook salmon (September), and no flow would be released from the Thermalito Afterbay Outlet. During the remainder of the spawning period, flows in the Low Flow Channel would increase to 800 cfs (normal conditions under Alternative 2) and 100 cfs would be released from the Thermalito Afterbay Outlet. During extreme drought conditions, flow reductions from 800 cfs to 750 cfs in the Low Flow Channel would occur before the onset of spawning by fall-run Chinook salmon. Therefore, flow reductions during extreme drought conditions likely would not affect spawning by fall-run Chinook salmon in the Low Flow Channel. However, PHABSIM results indicate that a reduction in flow in the Low Flow Channel from 800 cfs to 750 cfs would reduce available spawning habitat from almost 100 percent of maximum WUA to 99 percent of maximum WUA. A 1 percent reduction in available spawning area, as indicated by a 1 percent reduction in WUA, is a small reduction and would be unlikely to affect spawning by fall-run Chinook salmon in the Low Flow Channel.

Under Alternative 2, flows and flow fluctuations occurring in the High Flow Channel are not expected to differ from flows or flow fluctuations that would occur under the No-

Action Alternative as described in Section 5.4.2.1, Water Quantity Environmental Effects. Because there would be no changes in flows or flow fluctuations in the High Flow Channel with implementation of Alternative 2 compared to the No-Action Alternative, Alternative 2 would not result in a change in the amount of spawning habitat available for fall-run Chinook salmon or in rates of redd dewatering occurring in the High Flow Channel.

Juvenile Rearing and Downstream Movement

Increased flows in the Low Flow Channel under Alternative 2 compared to the No-Action Alternative would increase river stage slightly and could potentially increase available rearing habitat for juvenile salmonids including fall-run Chinook salmon. However, the increase in river stage associated with a 200 cfs increase in flow likely would be insufficient to appreciably increase rearing habitat availability. Therefore, increased flows would have no affect on fall-run Chinook salmon juvenile rearing and downstream movement.

Flow fluctuations in the Low Flow Channel could potentially occur under Alternative 2 to meet water temperature objectives prescribed to protect fisheries resources, or through changes in total releases occurring between 800 and 1,200 cfs during the May 1 through June 15 period. Under Alternative 2, the maximum flow fluctuation in the Low Flow Channel would be 400 cfs. Flow fluctuations can result in juvenile salmonid stranding in isolation ponds or beach stranding. Isolation ponds do not occur in the Low Flow Channel below 1,200 cfs; therefore, no isolation pond–type stranding would be anticipated with implementation of Alternative 2. Beach stranding can occur with changes in water surface elevation from changes in flows. Juvenile salmonids tend to select deeper water with increased size and become less susceptible to beach-type stranding as they grow. Flow fluctuations in the Low Flow Channel with implementation of Alternative 2 would occur from May 1 through June 15, with a maximum flow fluctuation of 400 cfs. Typically flow fluctuations for water temperature control in the Low Flow Channel during the summer are 200 cfs or less. A large portion of the juvenile fall-run Chinook population emigrates from the Feather River system before May and therefore would not be subjected to potential beach stranding from flow fluctuations associated with implementation of Alternative 2. Those juvenile fall-run Chinook salmon with prolonged rearing periods would be larger and have deeper water depth rearing preferences before May; therefore, they are less susceptible to beach stranding from flow fluctuations. However, some beach-type stranding could occur due to flow fluctuations occurring under Alternative 2. Water temperature control-related flow changes typically are 200 cfs or less and occur in the summer when rearing juveniles are larger and have preference for deeper water. Therefore rearing juvenile fall-run Chinook salmon would not be susceptible to beach-type stranding resulting from water temperature control-related flow changes.

Implementation of Alternative 2 would not result in any change in the frequency or magnitude of flow fluctuations in the High Flow Channel compared to the No-Action Alternative; therefore, no change in the rate of stranding by juvenile fall-run Chinook salmon would occur in the High Flow Channel.

G-AQUA5.4.1.2 Water Temperature–related Effects

The analysis of relative habitat suitability includes an evaluation of overall relative habitat suitability based on water temperature index values. The analysis includes a comparison of habitat suitability component metrics between the No-Action Alternative and Alternative 2.

The Overall Habitat Suitability Index Value (OHSIV) presented on the bottom row of the habitat suitability analysis table describes the overall relative habitat suitability for each water temperature index value used for the evaluation of each fish species and life stage. This metric represents the total amount of time and area of suitable habitat for each fish species and life stage. Comparison of the OHSIV metric between alternatives indicates which alternative has the greatest amount of suitable habitat with water temperatures equal to or below each water temperature index value.

The “Minimum Percentage of Time Value” and “Maximum Percentage of Time Value” metrics presented in the habitat suitability analysis tables describe the percentage of time that water temperatures within the least and most suitable habitat unit are below each specified index value for each fish species and life stage evaluated, respectively.

In addition, the “Habitat Units at 100 Percent of Time” metric presented in the habitat suitability analysis tables describes the number of habitat units in which water temperatures are always at or below each index value used for each fish species and life stage evaluated.

The “Percentage of Time at Maximum Habitat Units” metric presented in the habitat suitability analysis tables describes the distribution of the population of data, which indicates the percentage of time that water temperatures are equal to or below each water temperature index value selected for each fish species and life stage evaluated in the greatest amount of habitat area. That is, the most area in which water temperatures are below each water temperature index value occurs for some percentage of the total time within the fish species and life stage period. The “Percentage of Time at Maximum Habitat Units” metric describes that peak amount of habitat percentage of time. Detailed descriptions of the methodology used in the derivation and calculation of each of the above metrics is presented in Section G-AQUA2.2.3 of Appendix G-AQUA2, Methodology.

Adult Immigration and Holding

Figures G-AQUA5.4-2, G-AQUA5.4-3, and G-AQUA5.4-4 show the proportion of time that habitat units are considered suitable for each water temperature index value selected. The area under each curve displayed in Figures G-AQUA5.4-2, G-AQUA5.4-3, and G-AQUA5.4-4 is equal, which allows for direct comparison of habitat suitability between alternatives.

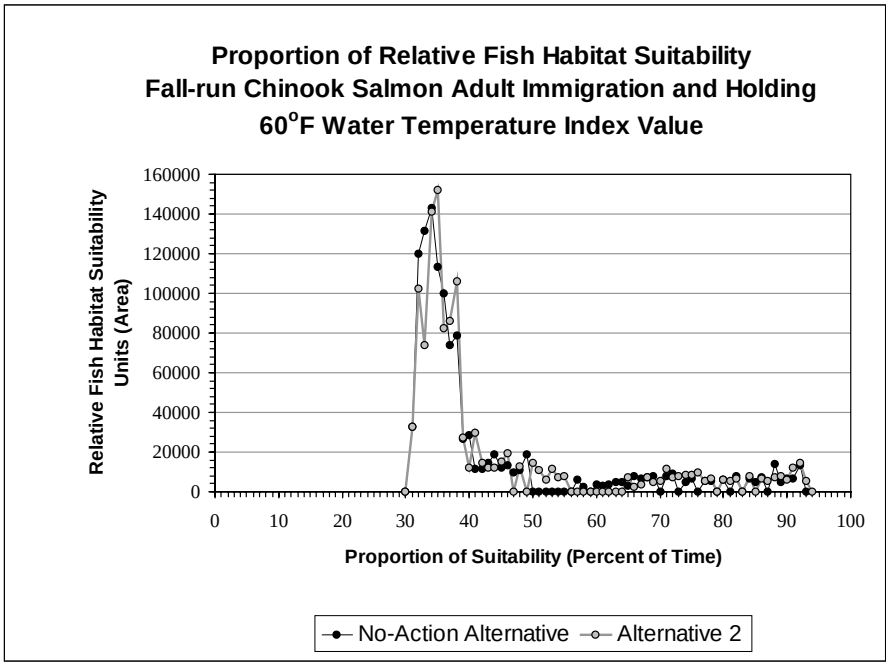

Figure G-AQUA5.4-2. Proportion of relative fish habitat suitability for fall-run Chinook salmon adult immigration and holding for the 60°F water temperature index value.

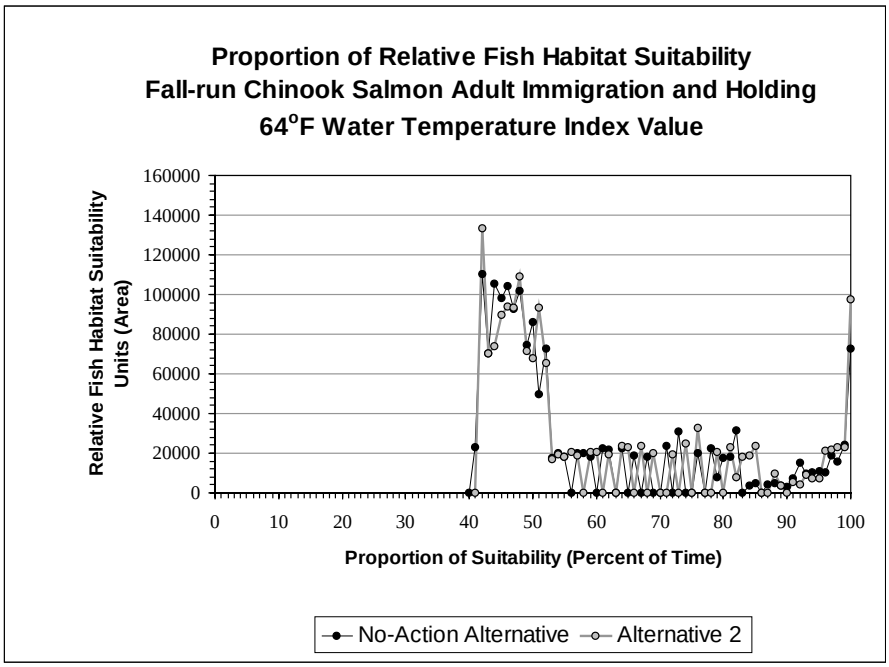

Figure G-AQUA5.4-3. Proportion of relative fish habitat suitability for fall-run Chinook salmon adult immigration and holding for the 64°F water temperature index value.

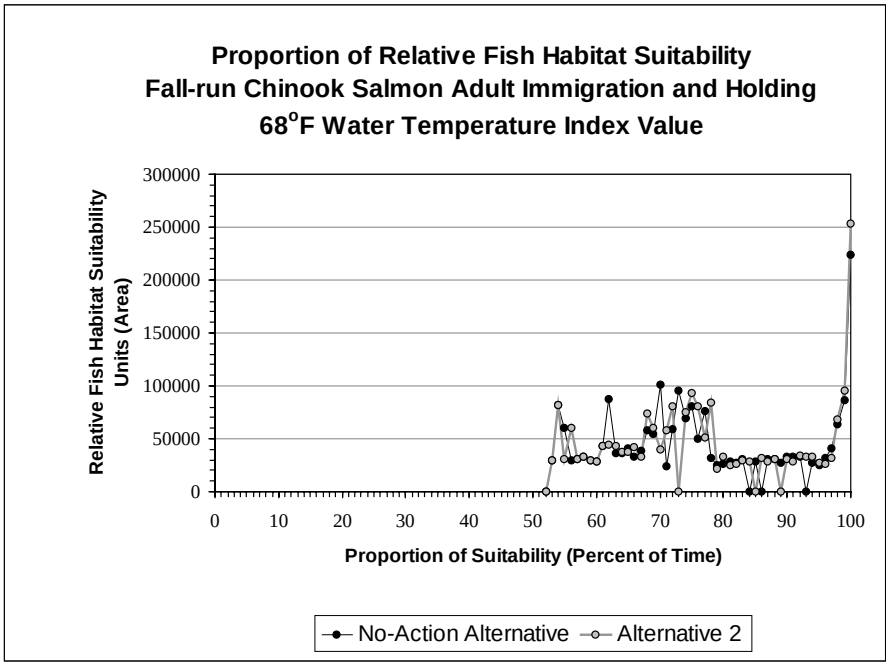

Figure G-AQUA5.4-4. Proportion of relative fish habitat suitability for fall-run Chinook salmon adult immigration and holding for the 68°F water temperature index value.

The OHSIV metrics presented in Table G-AQUA5.4-1 for fall-run Chinook salmon adult immigration and holding for the 60°F water temperature index value under the No-Action Alternative and Alternative 2 are 1,148,851 and 1,178,538, respectively. The difference in OHSIV between Alternative 2 and the No-Action Alternative is 29,687, which represents a 2.58 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative. The OHSIV for the 64°F water temperature index value under the No-Action Alternative and Alternative 2 are 1,599,013 and 1,629,108, respectively. The difference in OHSIV between Alternative 2 and the No-Action Alternative is 30,095, which represents a 1.88 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative. The OHSIV for the 68°F water temperature index value under the No-Action Alternative and Alternative 2 are 2,191,674 and 2,216,851, respectively. The difference in OHSIV between Alternative 2 and the No-Action Alternative is 25,176, which represents a 1.15 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative.

The Minimum Percentage of Time Value metric presented in Table G-AQUA5.4-1 for the fall-run Chinook salmon adult immigration and holding life stage did not change between the No-Action Alternative and Alternative 2 for the 60°F, and 68°F water temperature index values. The Minimum Percentage of Time Value metric for the 64°F water temperature index value under the No-Action Alternative and Alternative 2 are 41 and 42 percent, respectively. The 1 percent difference in Minimum Percentage of Time Value between the No-Action Alternative and Alternative 2 represents a small increase in the number of habitat units with the smallest amount of time and area with water temperatures below 64°F under Alternative 2 compared to the No-Action Alternative.

Table G-AQUA5.4-1. Overall habitat suitability index value comparison between the No-Action Alternative and Alternative 2 for fall-run Chinook salmon adult immigration and holding.

Water Temperature Index Value	60°F	64°F	68°F
No-Action Alternative			
Minimum Percentage of Time Value	31%	41%	53%
Maximum Percentage of Time Value	92%	100%	100%
Habitat Units at 100 Percent of Time	0	72,837	224,272
Percentage of Time at Maximum Habitat Units	34%	42%	100%
OHSIV	1,148,851	1,599,013	2,191,674
Alternative 2			
Minimum Percentage of Time Value	31%	42%	53%
Maximum Percentage of Time Value	93%	100%	100%
Habitat Units at 100 Percent of Time	0	97,307	253,442
Percentage of Time at Maximum Habitat Units	35%	42%	100%
OHSIV	1,178,538	1,629,108	2,216,851
Percent Change	2.58%	1.88%	1.15%

The Maximum Percentage of Time Value metric presented in Table G-AQUA5.4-1 for the fall-run Chinook salmon adult immigration and holding did not change between the No-Action Alternative and Alternative 2 for the 64°F and 68°F water temperature index values. The Maximum Percentage of Time Value metric for the 60°F water temperature index value under the No-Action Alternative and Alternative 2 are 92 percent and 93 percent, respectively. The 1 percent difference in Maximum Percentage of Time Value between the No-Action Alternative and Alternative 2 represents a small increase in the number of habitat units with the greatest amount of time and area with water temperatures below 60°F under Alternative 2 compared to the No-Action Alternative.

The Habitat Units at 100 Percent of Time metric presented in Table G-AQUA5.4-1 for the fall-run Chinook salmon adult immigration and holding life stage did not change between the No-Action Alternative and Alternative 2 for the 60°F water temperature index value. The Habitat Units at 100 Percent of Time for the 64°F water temperature index value under the No-Action Alternative and Alternative 2 are 72,837 and 97,307, respectively. The difference in Habitat Units at 100 Percent of Time between Alternative 2 and the No-Action Alternative is 24,470, which represents approximately a 34 percent increase in the amount of habitat area under Alternative 2 compared to the No-Action Alternative in which water temperatures are always at or below 64°F. The Habitat Units at 100 Percent of Time for the 68°F water temperature index value under the No-Action Alternative and Alternative 2 are 224,272 and 253,442, respectively. The difference in Habitat Units at 100 Percent of Time between Alternative 2 and the No-Action Alternative is 29,170, which represents approximately a 13 percent increase in the amount of habitat area under Alternative 2 compared to the No-Action Alternative in which water temperatures are always at or below 68°F.

A 34 percent increase in the number of habitat units in which water temperatures are always at or below 64°F and above 60°F represents an increase in habitat under Alternative 2 in which specific biological effects could potentially occur to immigrating and holding adult fall-run Chinook salmon, such as increased incidence of disease, decreased adult survival, decreased egg viability, and increased latent embryonic abnormalities and mortalities (Berman 1990; EPA 2003; ODEQ 1995; USFWS 1995). A 13 percent increase in the number of habitat units in which water temperatures are always at or below 68°F and above 64°F represents an increase in habitat under Alternative 2 in which specific biological effects could potentially occur to immigrating and holding adult fall-run Chinook salmon, such as further increased incidence of disease, additional decreased adult survival, additional decreased egg viability, and additional increased latent embryonic abnormalities and mortalities (Berman 1990; EPA 2003; Marine 1992). A detailed description of the potential effects that could occur to immigrating and holding adult fall-run Chinook salmon from exposure to water temperatures above each water temperature index value is presented in Appendix G-AQUA2.2.3.

The Percentage of Time at Maximum Habitat Units metric presented in Table G-AQUA5.4-1 for the fall-run Chinook salmon adult immigration and holding life stage did not change between the No -Action Alternative and Alternative 2 for the 64°F or 68°F water temperature index values. The Percentage of Time at Maximum Habitat Units metric presented for the fall-run Chinook salmon adult immigration and holding life stage for the 60°F water temperature index value under the No -Action Alternative and Alternative 2 are 34 percent and 35 percent, respectively. The difference in Percentage of Time at Maximum Habitat Units between Alternative 2 and the No -Action Alternative is 1 percent, which represents an increase in the percentage of time that the habitat is suitable in the greatest area.

Adult Spawning and Embryo Incubation

Figures G-AQUA5.4-5, G-AQUA5.4-6, G-AQUA5.4-7, and G-AQUA5.4-8 show the proportion of time that habitat units are considered suitable for each water temperature index value selected. The area under each curve displayed in Figures G-AQUA5.4-5, G-AQUA5.4-6, G-AQUA5.4-7, and G-AQUA5.4-8 is equal, which allows for direct comparison of habitat suitability between alternatives.

The OHSIV metrics presented in Table G-AQUA5.4-2 for fall-run Chinook salmon adult spawning and embryo incubation for the 56°F water temperature index value under the No-Action Alternative and Alternative 2 are 91,070 and 93,363, respectively. The difference in OHSIV between Alternative 2 and the No-Action Alternative is 2,293, which represents a 2.52 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative. The OHSIV for the 58°F water temperature index value under the No-Action Alternative and Alternative 2 are 105,231 and 108,004, respectively. The difference in OHSIV between Alternative 2 and the No-Action Alternative is 2,773, which represents a 2.63 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative. The OHSIV for the 60°F water temperature index value under the

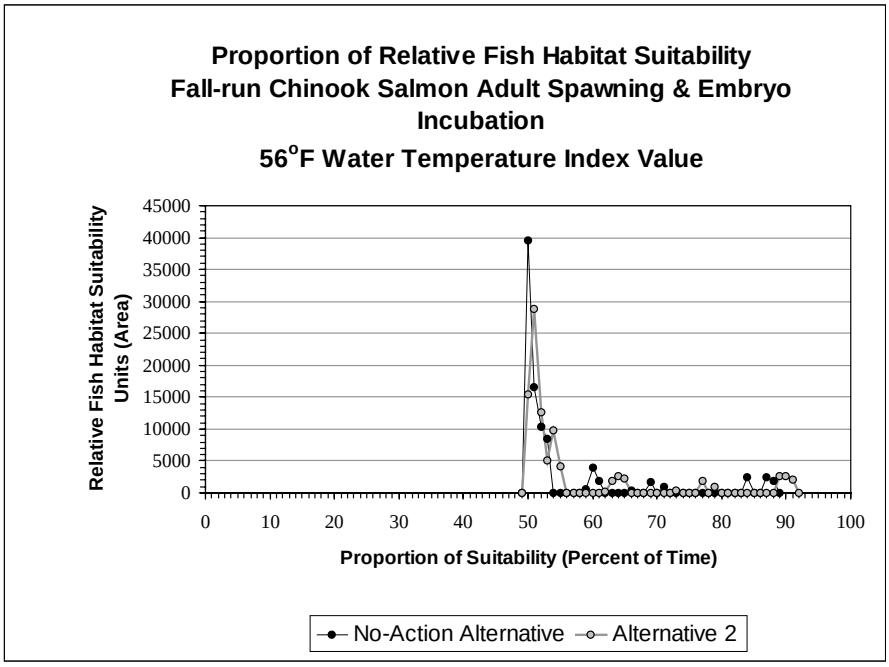

Figure G-AQUA5.4-5. Proportion of relative fish habitat suitability for fall-run Chinook salmon adult spawning and embryo incubation for the 56°F water temperature index value.

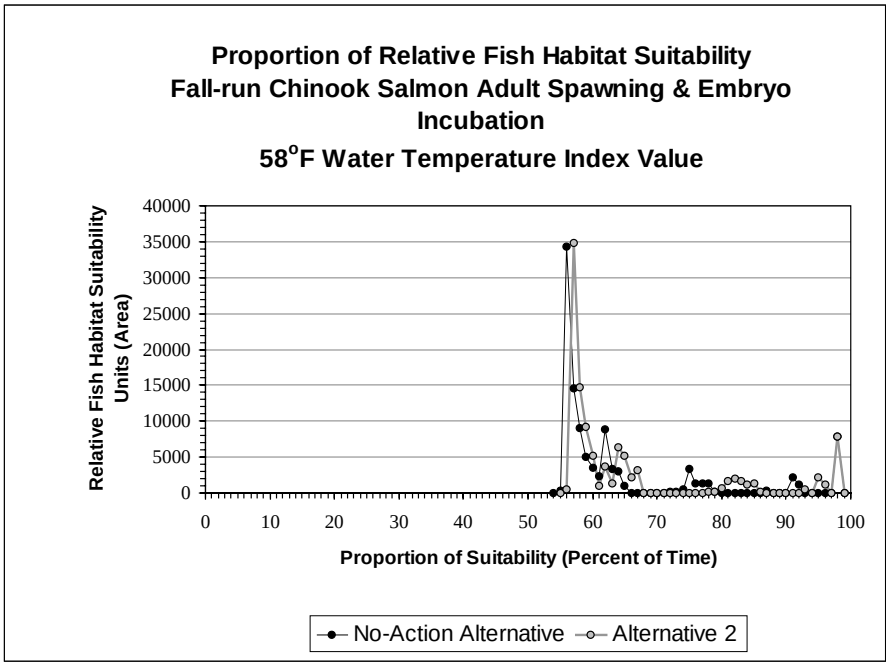

Figure G-AQUA5.4-6. Proportion of relative fish habitat suitability for fall-run Chinook salmon adult spawning and embryo incubation for the 58°F water temperature index value.

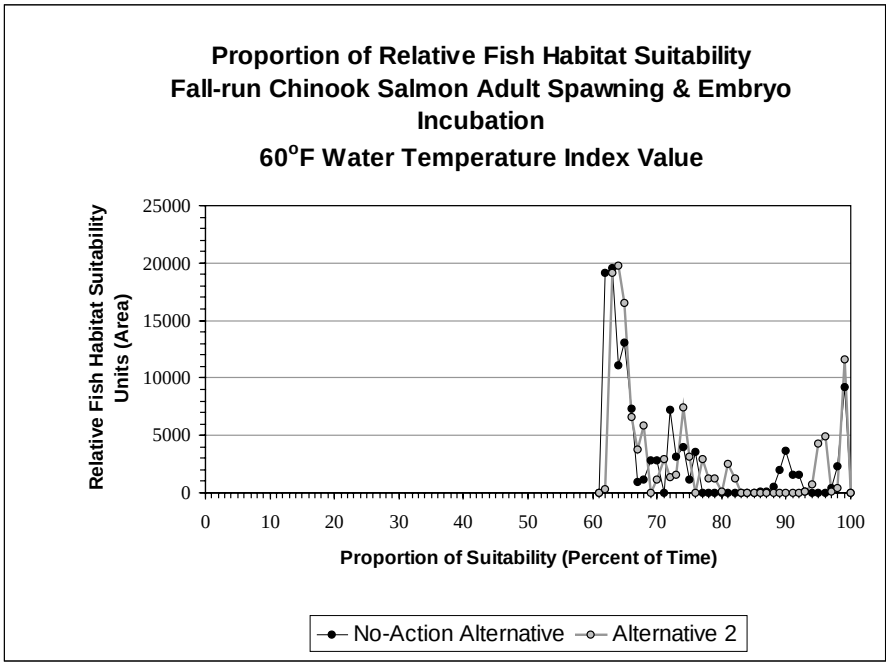

Figure G-AQUA5.4-7. Proportion of relative fish habitat suitability for fall-run Chinook salmon adult spawning and embryo incubation for the 60°F water temperature index value.

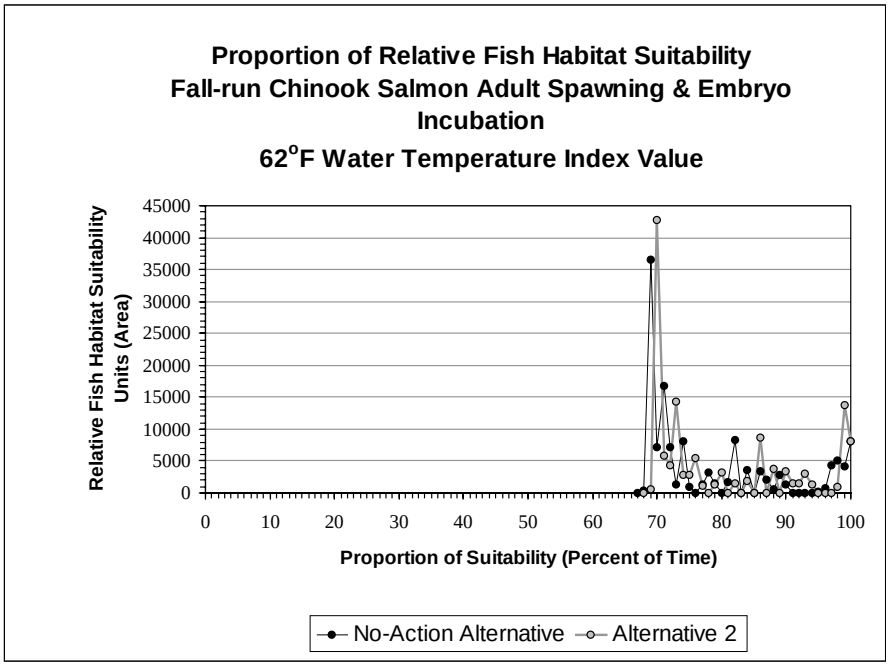

Figure G-AQUA5.4-8. Proportion of relative fish habitat suitability for fall-run Chinook salmon adult spawning and embryo incubation for the 62°F water temperature index value.

Table G-AQUA5.4-2. Overall habitat suitability index value comparison between the No-Action Alternative and Alternative 2 for fall-run Chinook salmon adult spawning and embryo incubation.

Water Temperature Index Value	56°F	58°F	60°F	62°F
No-Action Alternative				
Minimum Percentage of Time Value	50%	55%	62%	68%
Maximum Percentage of Time Value	88%	98%	99%	100%
Habitat Units at 100 Percent of Time	0	0	0	8,020
Percentage of Time at Maximum Habitat Units	50%	56%	63%	69%
OHSIV	91,070	105,231	118,429	130,823
Alternative 2				
Minimum Percentage of Time Value	50%	56%	62%	69%
Maximum Percentage of Time Value	91%	98%	99%	100%
Habitat Units at 100 Percent of Time	0	0	0	8,020
Percentage of Time at Maximum Habitat Units	51%	57%	64%	70%
OHSIV	93,363	108,004	121,142	133,455
Percent Change	2.52%	2.63%	2.29%	2.01%

No-Action Alternative and Alternative 2 are 118,429 and 121,142, respectively. The difference in OHSIV between Alternative 2 and the No-Action Alternative is 2,713, which represents a 2.29 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative. The OHSIV for the 62°F water temperature index value under the No-Action Alternative and Alternative 2 are 130,823 and 133,455, respectively. The difference in OHSIV between the No-Action Alternative and existing conditions is 2,632, which represents a 2.01 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative.

The Minimum Percentage of Time Value metric presented in Table G-AQUA5.4-2 for the fall-run Chinook salmon adult spawning and embryo incubation life stage did not change between Alternative 2 and the No-Action Alternative for the 56°F and 60°F water temperature index values. The Minimum Percentage of Time Value metric for the 58°F water temperature index value under the No-Action Alternative and Alternative 2 are 55 and 56 percent, respectively. The 1 percent difference in Minimum Percentage of Time Value between Alternative 2 and the No-Action Alternative represents a small increase in the number of habitat units with the smallest amount of time and area with water temperatures below 58°F under Alternative 2 compared to the No-Action Alternative. The Minimum Percentage of Time Value metric for the 62°F water temperature index value under the No-Action Alternative and Alternative 2 are 68 and 69 percent, respectively. The 1 percent difference in Minimum Percentage of Time Value between the No-Action Alternative and Alternative 2 represents a small increase in the number of habitat units with the smallest amount of time and area with water temperatures below 62°F under Alternative 2 compared to the No-Action Alternative.

The Maximum Percentage of Time Value metric presented in Table G-AQUA5.4-2 for the fall-run Chinook salmon adult spawning and embryo incubation life stage did not change between Alternative 2 and the No-Action Alternative for the 58°F, 60°F or 62°F water temperature index values. The Maximum Percentage of Time Value metric for the 56°F water temperature index value under the No-Action Alternative and Alternative 2 are 88 percent and 91 percent, respectively. The three percent difference in Maximum Percentage of Time Value between the No-Action Alternative and Alternative 2 represents an increase in the number of habitat units with the greatest amount of time and area with water temperatures below 56°F under Alternative 2 compared to the No-Action Alternative.

The Habitat Units at 100 Percent of Time metric presented in Table G-AQUA5.4-2 for the fall-run Chinook salmon adult spawning and embryo incubation life stage did not change between Alternative 2 and the No-Action Alternative for any of the water temperature index values selected.

The Percentage of Time at Maximum Habitat Units metric presented in Table G-AQUA5.4-2 for the fall-run Chinook salmon adult spawning and embryo incubation life stage for the 56°F water temperature index value under the No-Action Alternative and Alternative 2 are 50 and 51 percent, respectively. The difference in Percentage of Time at Maximum Habitat Units between Alternative 2 and the No -Action Alternative is 1 percent, which represents an increase in the percentage of time that the habitat is suitable in the greatest area. The Percentage of Time at Maximum Habitat Units metric for the 58°F water temperature index value under the No-Action Alternative and Alternative 2 are 56 and 57 percent, respectively. The difference in Percentage of Time at Maximum Habitat Units between Alternative 2 and the No -Action Alternative is 1 percent, which represents an increase in the percentage of time that the habitat is suitable in the greatest area. The Percentage of Time at Maximum Habitat Units metric for the 60°F water temperature index value under the No-Action Alternative and Alternative 2 are 63 and 64 percent, respectively. The difference in Percentage of Time at Maximum Habitat Units between Alternative 2 and the No -Action Alternative is 1 percent, which represents an increase in the percentage of time that the habitat is suitable in the greatest area. The Percentage of Time at Maximum Habitat Units metric for the 62°F water temperature index value under the No-Action Alternative and Alternative 2 are 69 and 70 percent, respectively. The difference in Percentage of Time at Maximum Habitat Units between Alternative 2 and the No -Action Alternative is 1 percent, which represents an increase in the percentage of time that the habitat is suitable in the greatest area.

Juvenile Rearing and Downstream Movement

Figures G-AQUA5.4-9, G-AQUA5.4-10, G-AQUA5.4-11, G-AQUA5.4-12, G-AQUA5.4-13, and G-AQUA5.4-14 show the proportion of time that habitat units are considered suitable for each water temperature index value selected. The area under each curve displayed in Figures G-AQUA5.4-9, G-AQUA5.4-10, G-AQUA5.4-11, G-AQUA5.4-12, G-AQUA5.4-13, and G-AQUA5.4-14 is equal, which allows for direct comparison of habitat suitability between alternatives.

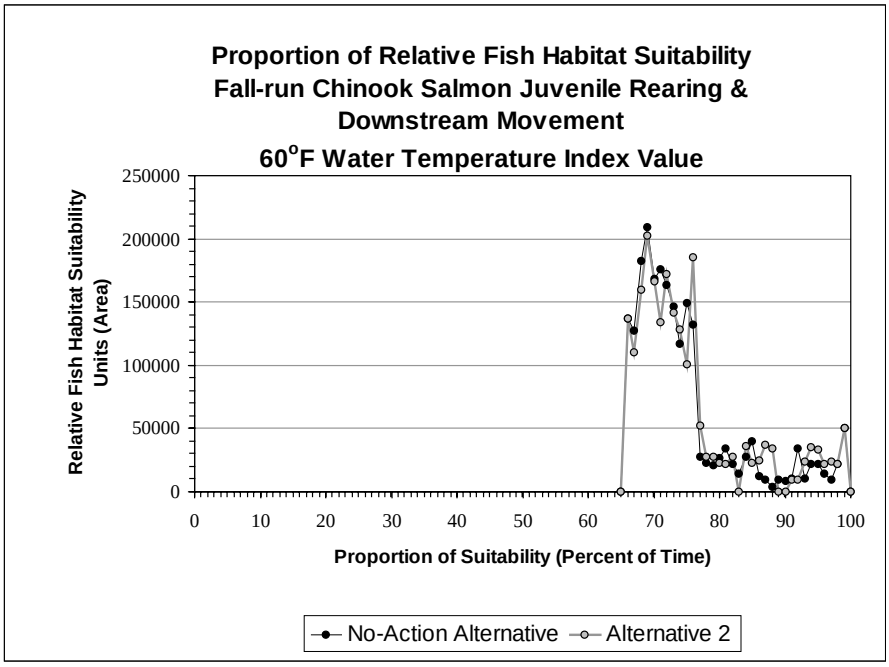

Figure G-AQUA5.4-9. Proportion of relative fish habitat suitability for fall-run Chinook salmon juvenile rearing and downstream movement for the 60°F water temperature index value.

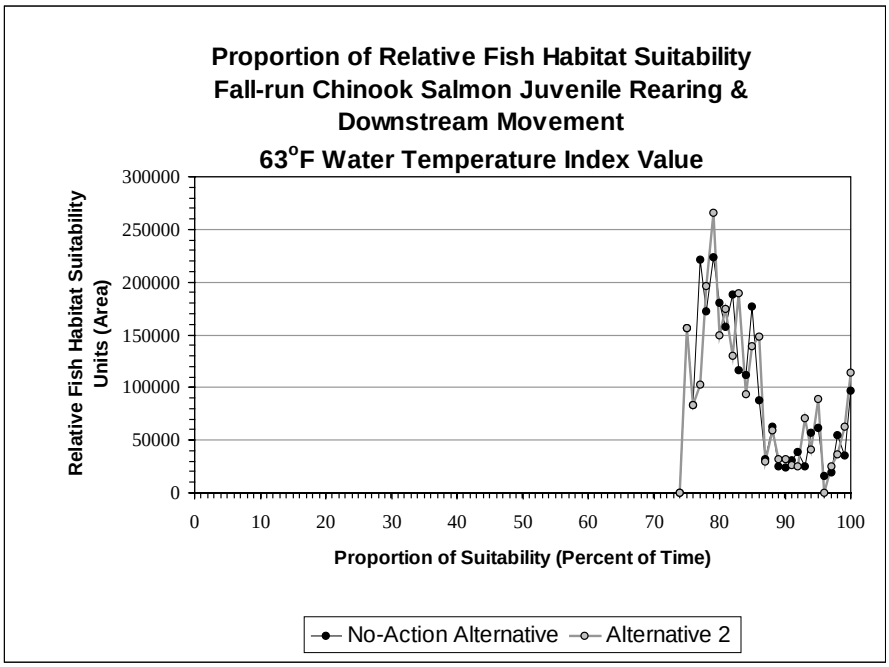

Figure G-AQUA5.4-10. Proportion of relative fish habitat suitability for fall-run Chinook salmon juvenile rearing and downstream movement for the 63°F water temperature index value.

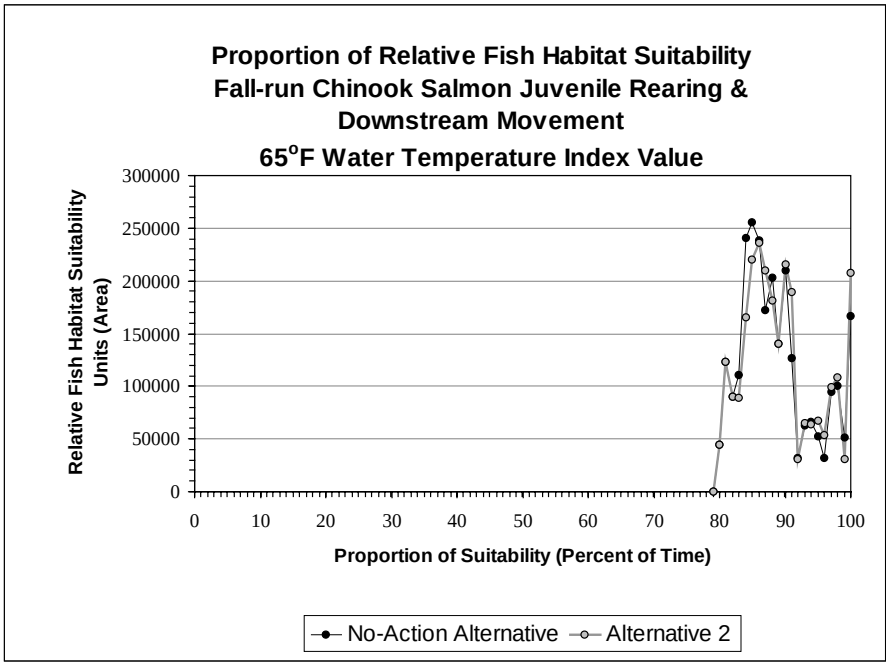

Figure G-AQUA5.4-11. Proportion of relative fish habitat suitability for fall-run Chinook salmon juvenile rearing and downstream movement for the 65°F water temperature index value.

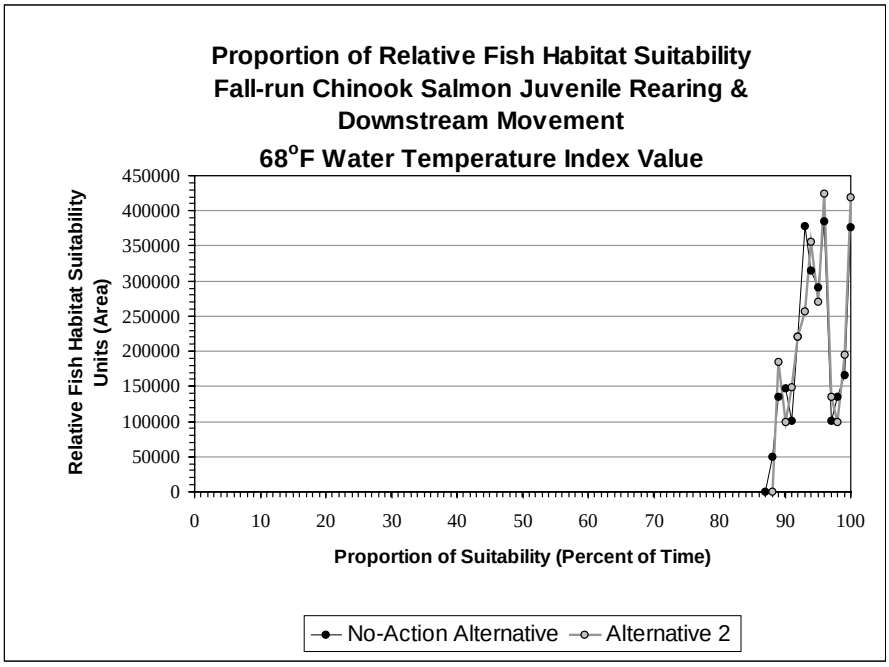

Figure G-AQUA5.4-12. Proportion of relative fish habitat suitability for fall-run Chinook salmon juvenile rearing and downstream movement for the 68°F water temperature index value.

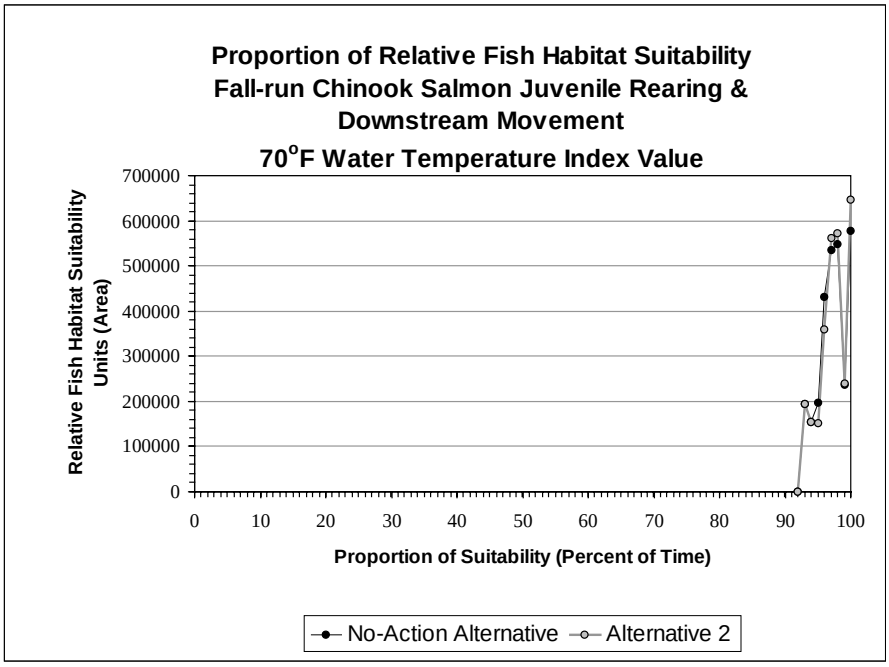

Figure G-AQUA5.4-13. Proportion of relative fish habitat suitability for fall-run Chinook salmon juvenile rearing and downstream movement for the 70°F water temperature index value.

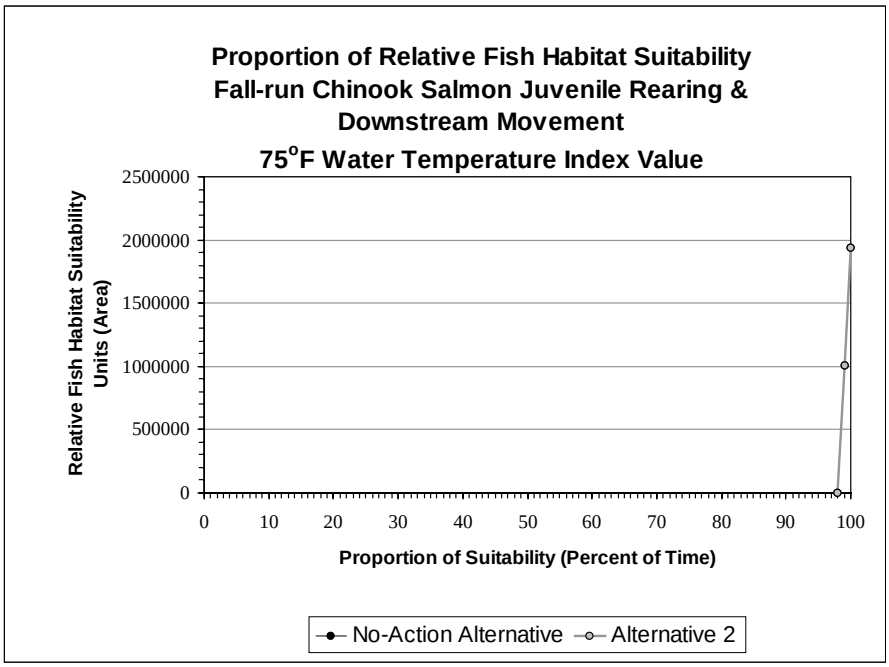

Figure G-AQUA5.4-14. Proportion of relative fish habitat suitability for fall-run Chinook salmon juvenile rearing and downstream movement for the 75°F water temperature index value.

The OHSIV metrics presented in Table G-AQUA5.4-3 for fall-run Chinook salmon juvenile rearing and downstream movement for the 60°F water temperature index value under the No-Action Alternative and Alternative 2 are 2,180,180 and 2,200,952, respectively. The difference in OHSIV between Alternative 2 and the No-Action Alternative is 20,772, which represents a 0.95 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative. The OHSIV for the 63°F water temperature index value under existing conditions and the No-Action Alternative are 2,453,678 and 2,470,311, respectively. The difference in OHSIV between Alternative 2 and the No-Action Alternative is 16,633, which represents a 0.68 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative. The OHSIV for the 65°F water temperature index value under the No-Action Alternative and Alternative 2 are 2,616,587 and 2,631,166, respectively. The difference in OHSIV between Alternative 2 and the No-Action Alternative is 14,578, which represents a 0.56 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative. The OHSIV for the 68°F water temperature index value under the No-Action Alternative and Alternative 2 are 2,800,642 and 2,807,225, respectively. The difference in OHSIV between Alternative 2 and the No-Action Alternative is 6,583, which represents a 0.24 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative. The OHSIV for the 70°F water temperature index value under the No-Action Alternative and Alternative 2 are 2,874,312 and 2,878,257, respectively. The difference in OHSIV between Alternative 2 and the No-Action Alternative is 3,945, which represents a 0.14 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative. The OHSIV for the 75°F water temperature index value the No-Action Alternative and Alternative 2 are 2,946,916 and 2,946,916, respectively, representing no difference in overall habitat suitability between the No-Action Alternative and Alternative 2 for the 75°F water temperature index value.

The Minimum Percentage of Time Value metric presented in Table G-AQUA5.4-3 for the fall-run Chinook salmon juvenile rearing and downstream movement life stage did not change between Alternative 2 and the No-Action Alternative for the 60°F, 63°F, 65°F, 70°F, or 75°F water temperature index values selected. The Minimum Percentage of Time Value metric for the fall-run Chinook salmon juvenile rearing and downstream movement for the 68°F water temperature index value under the No-Action Alternative and Alternative 2 are 88 percent and 89 percent, respectively. The 1 percent difference in Minimum Percentage of Time Value between Alternative 2 and the No-Action Alternative represents an increase in the number of habitat units with the smallest amount of time and area with water temperatures below 68°F under Alternative 2 compared to the No-Action Alternative.

The Maximum Percentage of Time Value metric presented in Table G-AQUA5.4-3 for the fall-run Chinook salmon juvenile rearing and downstream movement life stage did not change between Alternative 2 and the No-Action Alternative for any of the water temperature index values selected.

Table G-AQUA5.4-3. Overall habitat suitability index value comparison between the No-Action Alternative and Alternative 2 for fall-run Chinook salmon juvenile rearing and downstream movement.

Water Temperature Index Value	60°F	63°F	65°F	68°F	70°F	75°F
No-Action Alternative						
Minimum Percentage of Time Value	66%	75%	80%	88%	93%	99%
Maximum Percentage of Time Value	99%	100%	100%	100%	100%	100%
Habitat Units at 100 Percent of Time	0	97,307	166,409	376,160	578,584	1,938,161
Percentage of Time at Maximum Habitat Units	69%	79%	85%	96%	100%	100%
OHSIV	2,180,180	2,453,678	2,616,587	2,800,642	2,874,312	2,946,916
Alternative 2						
Minimum Percentage of Time Value	66%	75%	80%	89%	93%	99%
Maximum Percentage of Time Value	99%	100%	100%	100%	100%	100%
Habitat Units at 100 Percent of Time	0	113,590	208,095	418,862	646,443	1,938,161
Percentage of Time at Maximum Habitat Units	69%	79%	86%	96%	100%	100%
OHSIV	2,200,952	2,470,311	2,631,166	2,807,225	2,878,257	2,946,916
Percent Change	0.95%	0.68%	0.56%	0.24%	0.14%	0.00%

The Habitat Units at 100 Percent of Time metric presented in Table G-AQUA5.4-3 for the fall-run Chinook salmon juvenile rearing and downstream movement life stage did not change between Alternative 2 and the No-Action Alternative for the 60°F or 75°F water temperature index values. The Habitat Units at 100 Percent of Time for the 63°F water temperature index value under the No-Action Alternative and Alternative 2 are 97,307 and 113,590, respectively. The difference in Habitat Units at 100 Percent of Time between Alternative 2 and the No-Action Alternative is 16,283, which represents approximately a 17 percent increase in the amount of habitat area under Alternative 2 compared to the No-Action Alternative in which water temperatures are always at or below 63°F. The Habitat Units at 100 Percent of Time for the 65°F water temperature index value the No-Action Alternative and Alternative 2 are 166,409 and 208,095, respectively. The difference in Habitat Units at 100 Percent of Time between Alternative 2 and the No-Action Alternative is 41,686, which represents approximately a 25 percent increase in the amount of habitat area under Alternative 2 compared to the No-Action Alternative in which water temperatures are always at or below 65°F. The Habitat Units at 100 Percent of Time for the 68°F water temperature index value under the No-Action Alternative and Alternative 2 are 376,160 and 418,862, respectively. The difference in Habitat Units at 100 Percent of Time between Alternative 2 and the No-Action Alternative is 42,702, which represents approximately an 11 percent increase in the amount of habitat area under Alternative 2 compared to the No-Action Alternative in

which water temperatures are always at or below 68°F. The Habitat Units at 100 Percent of Time for the 70°F water temperature index value under the No-Action Alternative and Alternative 2 are 578,584 and 646,443, respectively. The difference in Habitat Units at 100 Percent of Time between Alternative 2 and the No-Action Alternative is 67,859, which represents approximately a 12 percent increase in the amount of habitat area under Alternative 2 compared to the No-Action Alternative in which water temperatures are always at or below 70°F.

A 17 percent increase in the number of habitat units in which water temperatures are always at or below 63°F and above 60°F represents an increase in habitat under Alternative 2 in which specific biological effects could potentially occur to rearing and downstream migrating juvenile fall-run Chinook salmon, such as acceleration or inhibition of smoltification, and decreased feeding and growth rates, (Clarke and Shelbourn 1985; Marine 1997; Zedonis and Newcomb 1997). A 25 percent increase in the number of habitat units in which water temperatures are always at or below 65°F and above 63°F represents an increase in habitat under Alternative 2 in which specific biological effects could potentially occur to rearing and downstream migrating juvenile fall-run Chinook salmon, such as acceleration or inhibition of smoltification, decreased growth rates, and increased susceptibility to disease (Clarke and Shelbourn 1985; Marine 1997; Ordal and Pacha 1963; Zedonis and Newcomb 1997). An 11 percent increase in the number of habitat units in which water temperatures are always at or below 68°F and above 65°F represents an increase in habitat under Alternative 2 in which specific biological effects could potentially occur to rearing and downstream migrating juvenile fall-run Chinook salmon, such as acceleration or inhibition of smoltification, decreased growth rates, increased stress response, decreased metabolic efficiency, and increased mortality rates (Brett et al. 1982; Clarke and Shelbourn 1985; Independent Scientific Group 1996; Marine 1997; Ordal and Pacha 1963; Zedonis and Newcomb 1997). A 12 percent decrease in the number of habitat units in which water temperatures are always at or below 70°F and above 68°F represents an increase in habitat under Alternative 2 in which specific biological effects could potentially occur to rearing and downstream migrating juvenile fall-run Chinook salmon, such as increased incidence of disease, hyperactivity, decreased appetite, reduced growth rates, and increased mortality rates (McCullough 1999; Rich 1987). A detailed description of the potential effects that could occur to rearing and downstream migrating juvenile fall-run Chinook salmon from exposure to water temperatures above each water temperature index value is presented in Appendix G-AQUA2.2.3.

The Percentage of Time at Maximum Habitat Units metric presented in Table G-AQUA5.4-3 for the fall-run Chinook salmon juvenile rearing and downstream movement life stage did not change between Alternative 2 and the No-Action Alternative for the 60°F, 63°F, 68°F, 70°F or the 75°F water temperature index values. The Percentage of Time at Maximum Habitat Units presented for the fall-run Chinook salmon juvenile rearing and downstream movement life stage for the 65°F water temperature index value under the No-Action Alternative and Alternative 2 are 85 percent and 86 percent, respectively. The difference in Percentage of Time at Maximum Habitat Units between Alternative 2 and the No-Action Alternative is 1 percent, which represents a small increase in the percentage of time that the habitat is suitable in the greatest area.

G-AQUA5.4.1.3 Predation-related Effects

Changes in minimum flows in the Low Flow Channel are not expected to change the nature or rate of predation with implementation of Alternative 2. Water temperature changes would be very small and are not expected to change the distribution, species composition, consumption rates, or nature of predation in the lower Feather River. Adaptive management changes in steelhead hatchery release practices may reduce predation of juvenile fall-run Chinook salmon. The Large Woody Debris Supplementation and Improvement Program would improve juvenile rearing cover conditions, resulting in a reduction of predation rates on juvenile fall-run Chinook salmon.

G-AQUA5.4.1.4 Fisheries Management–related Effects

Hatchery

The Hatchery Adaptive Management Program included in Alternative 2 is the same as under the Proposed Action, with the exception of the inclusion of a water treatment facility for the hatchery water supply. (See Section G-AQUA4.4 in Appendix G-AQUA4 for an evaluation of the Hatchery Adaptive Management Program relative to the No-Action Alternative.) The hatchery water treatment facility could reduce the rate of incidence and severity of disease occurrences in the hatchery and would result in lower contributions of the accumulated disease pressure in the lower Feather River as a result.

Disease

Water temperature changes with implementation of Alternative 2 would be relatively small; therefore, no changes in water temperature–related interactions with the incidence of fish diseases are anticipated. The proposed hatchery water treatment could reduce the rate of incidence and severity of disease occurrences in the Feather River Fish Hatchery, which, as a result, would lower contributions of the accumulated disease pressure in the lower Feather River.

Fishing Regulations, Poaching, and Change in Recreational Access and Visitation

Section 5.10.2, Recreation Resources Environmental Effects, forecasts a one-third increase in recreation and angling activities with the No-Action Alternative and an approximately 51 percent increase in recreation and angling under Alternative 2 as compared to the existing condition. This would indicate an expected increase of approximately 18 percent in recreation and angling under Alternative 2 relative to the No-Action Alternative. A 18 percent increase in angling, with no other resources actions related to fisheries, would equate to increased angler harvest rates. Fishing access would be increased under Alternative 2 with the implementation of several recreation facilities on the lower Feather River. (See Section 5.10.2.3 for additional information on recreation facilities and changes in visitation under Alternative 2.) No fishing zones in

proximity to the fish barrier weirs would require changes in fishing regulations with implementation of Alternative 2.

G-AQUA5.4.1.5 Summary of Potential Effects on Fall-run Chinook Salmon

Study plan report summaries addressing project effects on fall-run Chinook salmon are presented in Section G-AQUA1.5, Fisheries Management; Section G-AQUA1.8, Salmonids and Their Habitat in the Feather River Below the Fish Barrier Dam; Section G-AQUA1.10, Instream Flows and Fish Habitat; and Section G-AQUA1.11, Predation; of Appendix G-AQUA1, Affected Environment. A description of each fall-run Chinook salmon life stage and the time period associated with it is presented in Appendix G-AQUA1.

Effects on fall-run Chinook salmon associated with installation of fish barrier weirs, the Large Woody Debris Supplementation and Improvement Program, and the Gravel Supplementation and Improvement Program with implementation of Alternative 2 would not differ from those effects associated with the Proposed Action because the proposed PM&E measures are the same under Alternative 2 and the Proposed Action. Appendix G-AQUA4, Effects of the Proposed Action, describes the effects associated with each PM&E measure proposed for implementation under the Proposed Action. Additionally, water temperature–related effects resulting from changes in flows in the Low Flow Channel under Alternative 2 are not expected to alter disease or predation effects because the changes in water temperature compared to the No-Action Alternative would be small.

Adult Immigration and Holding

Actions potentially affecting fall-run Chinook salmon adult immigration and holding include changes to instream flows and water temperatures in the Low Flow Channel. Side-channel habitat creation and enhancement, and a Hatchery Adaptive Management Program, as implemented under Alternative 2 would differ slightly from those PM&E measures as proposed for implementation under the Proposed Action; however, they would have the same types of effects on fall-run Chinook salmon adult immigration and holding compared to the No-Action Alternative. Appendix G-AQUA4, Effects of the Proposed Action, describes the effects associated with each PM&E measure proposed for implementation under the Proposed Action.

An increased instream flow of 800 cfs in the Low Flow Channel under Alternative 2 could potentially have a beneficial effect on immigrating fall-run Chinook salmon by increasing lower Feather River stage elevations. Although stage increases would be small, shallow riffles could potentially become deeper, reducing the effort required by immigrating adult fall-run Chinook salmon to proceed through shallow riffles. Additionally, increased flows would slightly reduce average daily water temperatures, thereby increasing overall habitat suitability for each water temperature index value during the immigration and holding period for adult fall-run Chinook salmon.

Overall, implementation of Alternative 2 would have a beneficial effect on fall-run Chinook salmon adult immigration.

Spawning and Embryo Incubation

Actions potentially affecting fall-run Chinook salmon adult spawning and embryo incubation include a Hatchery Adaptive Management Program, creation and enhancement of side-channel habitat, and changes to instream flows and water temperatures in the Low Flow Channel. Many of the effects of a Hatchery Adaptive Management Program would be the same as those identified for the Proposed Action (see Appendix G-AQUA4), relative to the No-Action Alternative, with one exception. The water treatment program associated with the Hatchery Adaptive Management Program under Alternative 2 would potentially have an additional beneficial effect on incubating fall-run Chinook salmon embryos by minimizing the potential for disease-associated embryonic mortality in the Feather River Fish Hatchery and by reducing the accumulated disease pressure in the lower Feather River.

Creation and enhancement of side-channel habitat under Alternative 2 would provide an additional benefit over the Proposed Action compared to the No-Action Alternative because there would be a greater area of side channel under Alternative 2. The creation of side-channel habitat in Alternative 2 would result in an increase in the amount of spawning area for fall-run Chinook salmon.

An increase in instream flows in the Low Flow Channel from 600 cfs to 800 cfs during the adult spawning and embryo incubation period would increase WUA from 91 percent of maximum to almost 100 percent of maximum. Additionally, during extreme drought years, decreases in flow from 800 cfs to 750 cfs likely would not affect fall-run Chinook salmon adult spawning and embryo incubation because 750 cfs represents approximately 99 percent of maximum WUA, while 800 cfs represents almost 100 percent of maximum WUA. Reduced average daily water temperatures under Alternative 2 result in increased overall habitat suitability for each water temperature index value for fall-run Chinook salmon adult spawning and embryo incubation.

Overall, implementation of Alternative 2 would result in a beneficial effect on fall-run Chinook salmon adult spawning and embryo incubation.

Juvenile Rearing and Downstream Movement

Actions potentially affecting fall-run Chinook salmon juvenile rearing and downstream movement include a Hatchery Adaptive Management Program, side-channel habitat creation, and changes to instream flows and water temperatures in the Low Flow Channel. Many of the effects of a Hatchery Adaptive Management Program would be the same as those identified for the Proposed Action (see Appendix G-AQUA4), relative to the No-Action Alternative, with one exception. The water treatment program associated with the Hatchery Adaptive Management Program under Alternative 2 would potentially have an additional beneficial effect on rearing fall-run Chinook salmon

juveniles by minimizing the potential for disease-associated mortality in the hatchery and by reducing the accumulated disease pressure in the lower Feather River.

Creation of side-channel habitat under Alternative 2 would increase the amount of juvenile rearing habitat available compared to the No-Action Alternative. Increased flows and lower water temperature targets at Robinson Riffle with implementation of Alternative 2 would be expected to slightly reduce average daily water temperatures during the juvenile rearing and downstream movement period for fall-run Chinook salmon. However, model results indicate that differences in habitat suitability due to decreased water temperatures are less than 1 percent between the No-Action Alternative and Alternative 2, and as such, are considered below the detection limits of the analytical tools utilized in the habitat suitability analysis. Therefore, changes in water temperature would not affect fall-run Chinook salmon juvenile rearing and downstream movement. However, flow fluctuations ranging from 800 cfs to 1,200 cfs in the Low Flow Channel could occur from May 1 through June 15, when total releases up to 1,200 cfs are routed through the Low Flow Channel. This could result in an adverse effect on fall-run Chinook salmon juvenile rearing and downstream movement by increasing the potential for beach stranding. Based on the emigration timing of most juvenile Chinook salmon in the Feather River, and on the preference for increased water depths as rearing juveniles grow larger later in the rearing season, it is unlikely that any substantial change in the rate of beach stranding would occur as a result of flow fluctuations in the Low Flow Channel from May 1 through June 15. Water temperature control-related changes in flow from 800 cfs to approximately 1,000 cfs later in the summer season also would not be expected to result in beach stranding of juvenile fall-run Chinook salmon.

Overall, implementation of Alternative 2 would result in a beneficial effect on fall-run Chinook salmon juvenile rearing and downstream movement.

Conclusion

Under Alternative 2, flows and flow fluctuations occurring in the High Flow Channel are not expected to differ from those occurring under the No-Action Alternative (described in Section 5.4.2.1). Therefore, implementation of Alternative 2 would not result in a flow-related change in the quantity, quality, or distribution of habitat for fall-run Chinook salmon in the High Flow Channel. Habitat improvement programs including side-channel creation and enhancement and the Gravel Supplementation and Improvement Program and Large Woody Debris Supplementation and Improvement Program also would be beneficial for fall-run Chinook salmon habitat quality and quantity.

Based on the above summary of potential effects, implementation of Alternative 2 would result in an overall beneficial effect on fall-run Chinook salmon.

G-AQUA5.4.2 Spring-run Chinook Salmon

G-AQUA5.4.2.1 Flow-related Effects

Adult Immigration and Holding

An increased instream flow of 800 cfs in the Low Flow Channel under Alternative 2 could potentially have a beneficial effect on immigrating and holding spring-run Chinook salmon by increasing the lower Feather River stage elevation over potential critical riffles. Although stage increases would be small, shallow riffles could potentially become deeper, reducing effort required by immigrating adult spring-run Chinook salmon to proceed through shallow riffles. In addition, water depth would be increased, creating additional amounts of suitable holding habitat relative to water depths.

In addition to a base flow of 800 cfs in the Low Flow Channel, from May 1 through June 15 flows could increase to 1,200 cfs. Section 5.4.2.1, Water Quantity Environmental Effects, provides a detailed description of the circumstances under which flow increases to 1,200 cfs would occur in the Low Flow Channel. Increasing instream flow to 1,200 cfs would further increase river stage, further increasing holding habitat availability in the Low Flow Channel, providing an additional beneficial effect during the period of increased flows.

No flow changes relative to the No-Action Alternative are expected in the High Flow Channel with implementation of Alternative 2.

Adult Spawning and Embryo Incubation

Flow changes in the Low Flow Channel included in Alternative 2 would affect spring-run Chinook salmon adult spawning and embryo incubation in the same way that they would affect this life stage for fall-run Chinook salmon. Refer to the above discussion of adult spawning and embryo incubation by fall-run Chinook salmon for the evaluation of flow-related effects on adult spawning and embryo incubation by spring-run Chinook salmon.

Juvenile Rearing and Downstream Movement

Juvenile rearing and downstream movement is the same for spring-run Chinook salmon as for fall-run Chinook salmon, with the exception that spring-run Chinook salmon can rear in the lower Feather River year round. Flow changes in the Low Flow Channel included in Alternative 2 would affect the early portion of the juvenile rearing and downstream movement period for spring-run Chinook salmon in the same way that they would affect this life stage for fall-run Chinook salmon. Refer to the above discussion of juvenile rearing and downstream movement by fall-run Chinook salmon for the evaluation of flow-related effects on juvenile rearing and downstream movement by spring-run Chinook salmon during the early portion of this period. The later periods of extended juvenile rearing for spring-run Chinook salmon are not susceptible to any additional stranding type losses associated with implementation of Alternative 2

because of the increased size of the fish in the later rearing period and the preference for deeper water habitat as compared to the earlier rearing period.

G-AQUA5.4.2.2 Water Temperature–related Effects

The relative habitat suitability analysis includes an evaluation of overall relative habitat suitability based on water temperature index values. The analysis includes a comparison of habitat suitability component metrics between the No-Action Alternative and Alternative 2. The OHSIV analysis is described in the above discussion of temperature-related effects on fall-run Chinook salmon. Detailed descriptions of the methodology used in the derivation and calculation of each of the above metrics are presented in Section G-AQUA.2.2.3 of Appendix G-AQUA2, Methodology.

Adult Immigration and Holding

Figures G-AQUA5.4-15, G-AQUA5.4-16, and G-AQUA5.4-17 show the proportion of time that habitat units are considered suitable for each water temperature index value selected. The area under each curve displayed in Figures G-AQUA5.4-15, G-AQUA5.4-16, and G-AQUA5.4-17 is equal, which allows for direct comparison of habitat suitability between alternatives.

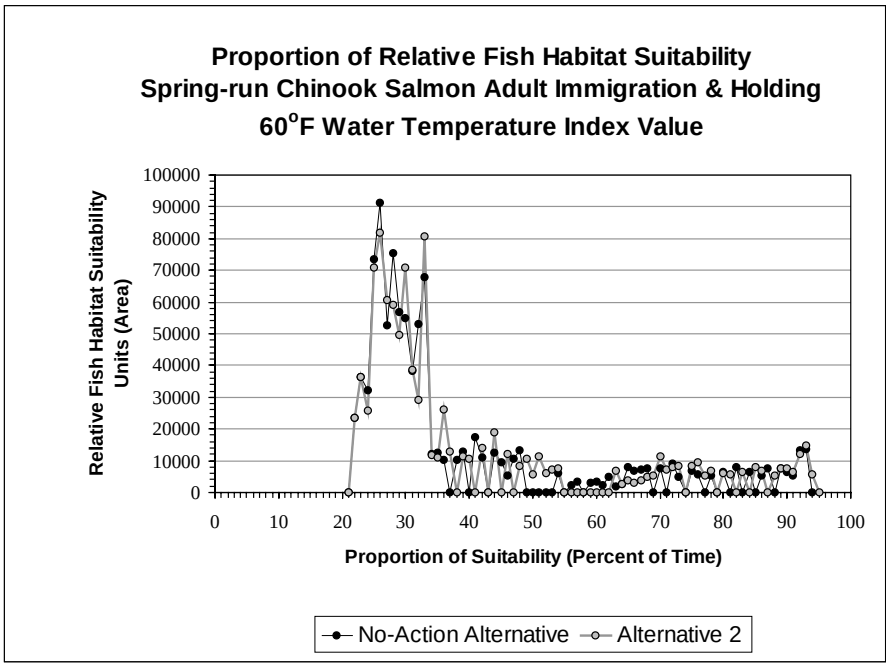

Figure G-AQUA5.4-15. Proportion of relative fish habitat suitability for spring-run Chinook salmon adult immigration and holding for the 60°F water temperature index value.

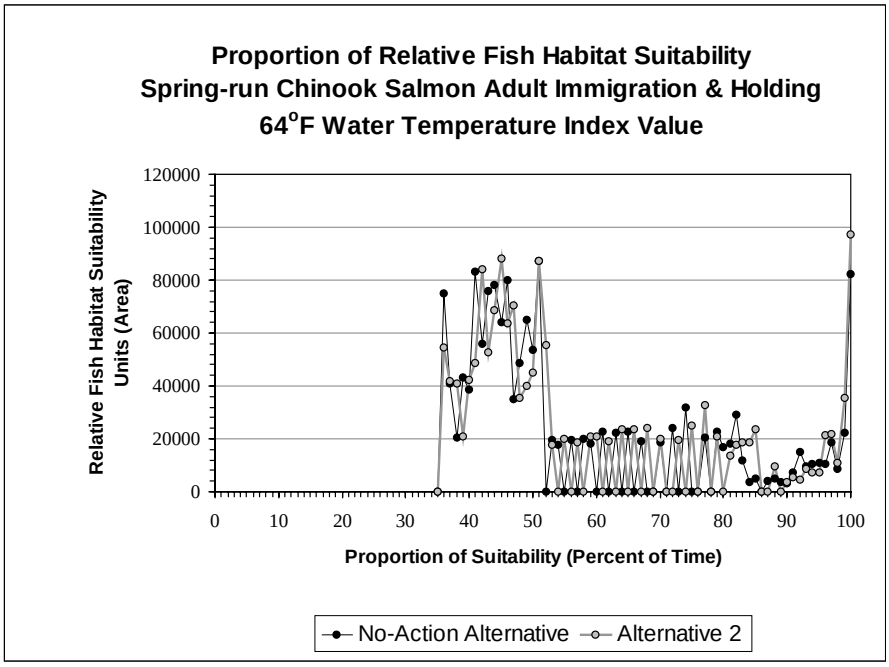

Figure G-AQUA5.4-16. Proportion of relative fish habitat suitability for spring-run Chinook salmon adult immigration and holding for the 64°F water temperature index value.

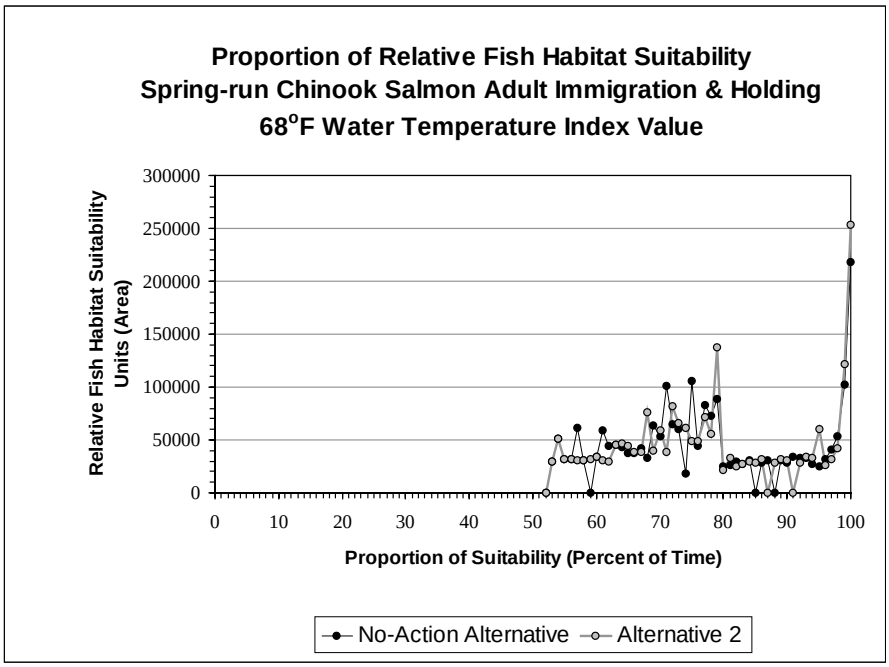

Figure G-AQUA5.4-17. Proportion of relative fish habitat suitability for spring-run Chinook salmon adult immigration and holding for the 68°F water temperature index value.

The OHSIV metrics presented in Table G-AQUA5.4-4 for spring-run Chinook salmon adult immigration and holding for the 60°F water temperature index value under the No-Action Alternative and Alternative 2 are 970,626 and 1,000,276, respectively. The difference in OHSIV between the No-Action Alternative and Alternative 2 is 29,650, which represents a 3.05 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative. The OHSIV for the 64°F water temperature index value under the No-Action Alternative and Alternative 2 are 1,538,763 and 1,572,453, respectively. The difference in OHSIV between Alternative 2 and the No-Action Alternative is 33,690, which represents a 2.19 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative. The OHSIV for the 68°F water temperature index value under the No-Action Alternative and Alternative 2 are 2,225,207 and 2,249,848, respectively. The difference in OHSIV between No-Action Alternative and existing conditions is 24,641, which represents a 1.11 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative.

Table G-AQUA5.4-4. Overall habitat suitability index value comparison between the No-Action Alternative and Alternative 2 for spring-run Chinook salmon adult immigration and holding.

Water Temperature Index Value	60°F	64°F	68°F
No-Action Alternative			
Minimum Percentage of Time Value	22%	36%	53%
Maximum Percentage of Time Value	93%	100%	100%
Habitat Units at 100 Percent of Time	0	82,362	218,450
Percentage of Time at Maximum Habitat Units	26%	51%	100%
OHSIV	970,626	1,538,763	2,225,207
Alternative 2			
Minimum Percentage of Time Value	22%	36%	53%
Maximum Percentage of Time Value	94%	100%	100%
Habitat Units at 100 Percent of Time	0	97,307	253,442
Percentage of Time at Maximum Habitat Units	26%	100%	100%
OHSIV	1,000,276	1,572,453	2,249,848
Percent Change	3.05%	2.19%	1.11%

The Minimum Percentage of Time Value metric presented in Table G-AQUA5.4-4 for the spring-run Chinook salmon adult immigration and holding life stage did not change between the No-Action Alternative and Alternative 2 for any of the water temperature index values selected.

The Maximum Percentage of Time Value metric presented in Table G-AQUA5.4-4 for the spring-run Chinook salmon adult immigration and holding life stage did not change between the No-Action Alternative and Alternative 2 for the 64°F and 68°F water temperature index values. The Maximum Percentage of Time Value for the 60°F water temperature index value under the No-Action Alternative and Alternative 2 are 93 percent and 94 percent, respectively. The 1 percent difference in Maximum Percentage

of Time Value between Alternative 2 and the No-Action Alternative represents a small increase in the number of habitat units with the greatest amount of time and area with water temperatures below 60°F under Alternative 2 compared to the No-Action Alternative.

The Habitat Units at 100 Percent of Time metric presented in Table G-AQUA5.4-4 for the spring-run Chinook salmon adult immigration and holding life stage did not change between the No-Action Alternative and Alternative 2 for the 60°F water temperature index value. The Habitat Units at 100 Percent of Time for the 64°F water temperature index value under the No-Action Alternative and Alternative 2 are 82,362 and 97,307, respectively. The difference in Habitat Units at 100 Percent of Time between Alternative 2 and the No-Action Alternative is 14,945, which represents approximately an 18 percent increase in the amount of habitat area under Alternative 2 compared to the No-Action Alternative in which water temperatures are always at or below 64°F. The Habitat Units at 100 Percent of Time for the 68°F water temperature index value under the No-Action Alternative and Alternative 2 are 218,450 and 253,442, respectively. The difference in Habitat Units at 100 Percent of Time between Alternative 2 and the No-Action Alternative is 34,992, which represents approximately a 16 percent increase in the amount of habitat area under Alternative 2 compared to the No-Action Alternative in which water temperatures are always at or below 68°F.

An 18 percent increase in the number of habitat units in which water temperatures are always at or below 64°F and above 60°F represents an increase in habitat under Alternative 2 in which specific biological effects could potentially occur to immigrating and holding adult spring-run Chinook salmon, such as increased incidence of disease, decreased adult survival, decreased egg viability, and increased latent embryonic abnormalities and mortalities (Berman 1990; EPA 2003; ODEQ 1995; USFWS 1995). A 16 percent increase in the number of habitat units in which water temperatures are always at or below 68°F and above 64°F represents an increase in habitat under Alternative 2 in which specific biological effects could potentially occur to immigrating and holding adult spring-run Chinook salmon, such as further increased incidence of disease, additional decreased adult survival, additional decreased egg viability, and additional increased latent embryonic abnormalities and mortalities (Berman 1990; EPA 2003; Marine 1992). A detailed description of the potential effects that could occur to immigrating and holding adult spring-run Chinook salmon from exposure to water temperatures above each water temperature index value is presented in Section G-AQUA2.2.3 of Appendix G-AQUA2.

The Percentage of Time at Maximum Habitat Units metric presented in Table G-AQUA5.4-4 for the spring-run Chinook salmon adult immigration and holding life stage did not change between the No-Action Alternative and Alternative 2 for the 60°F or the 68°F water temperature index values. The Percentage of Time at Maximum Habitat Units for the 64°F water temperature index value under the No-Action Alternative and Alternative 2 are 51 percent and 100 percent, respectively. The difference in Percentage of Time at Maximum Habitat Units between Alternative 2 and the No-Action Alternative is 49 percent, which represents an increase in the percentage of time that the habitat is suitable in the greatest area.

Adult Spawning and Embryo Incubation

Adult spawning and embryo incubation by spring-run Chinook salmon has the same life stage period and water temperature requirements as the same life stage for fall-run Chinook salmon. Refer to the above discussion of water temperature–related effects on adult spawning and embryo incubation by fall-run Chinook salmon.

Juvenile Rearing and Downstream Movement

Figures G-AQUA5.4-18, G-AQUA5.4-19, G-AQUA5.4-20, G-AQUA5.4-21, G-AQUA5.4-22, and G-AQUA5.4-23 show the proportion of time that habitat units are considered suitable for each water temperature index value selected. The area under each curve displayed in Figures G-AQUA5.4-18, G-AQUA5.4-19, G-AQUA5.4-20, G-AQUA5.4-21, G-AQUA5.4-22, and G-AQUA5.4-23 is equal, which allows for direct comparison of habitat suitability between alternatives.

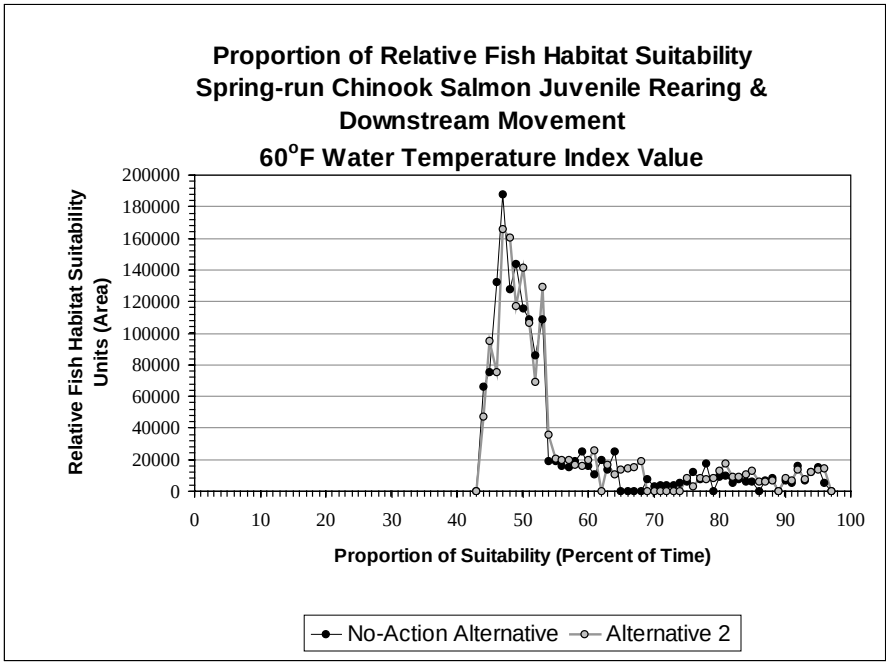

Figure G-AQUA5.4-18. Proportion of relative fish habitat suitability for spring-run Chinook salmon juvenile rearing and downstream movement for the 60°F water temperature index value.

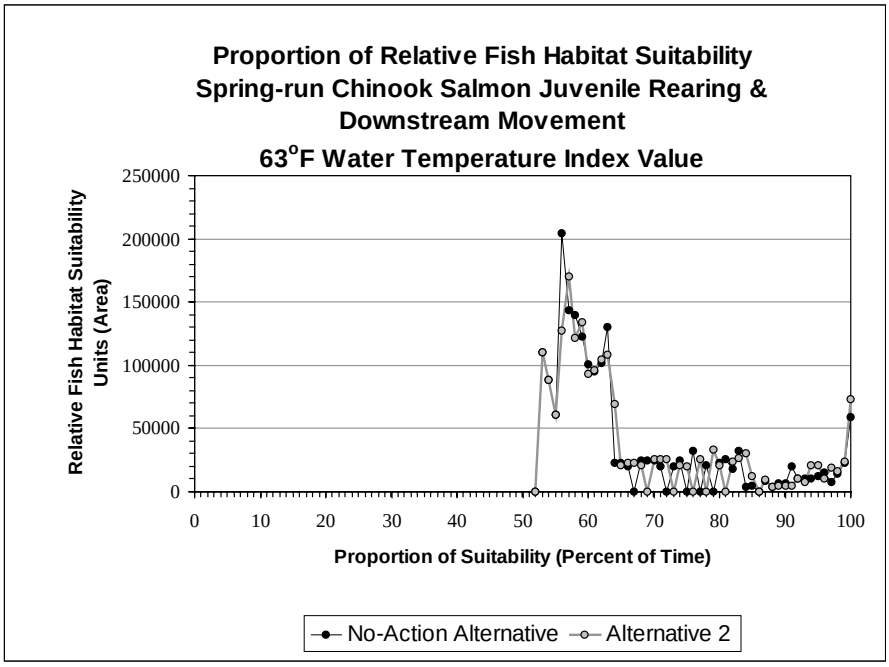

Figure G-AQUA5.4-19. Proportion of relative fish habitat suitability for spring-run Chinook salmon juvenile rearing and downstream movement for the 63°F water temperature index value.

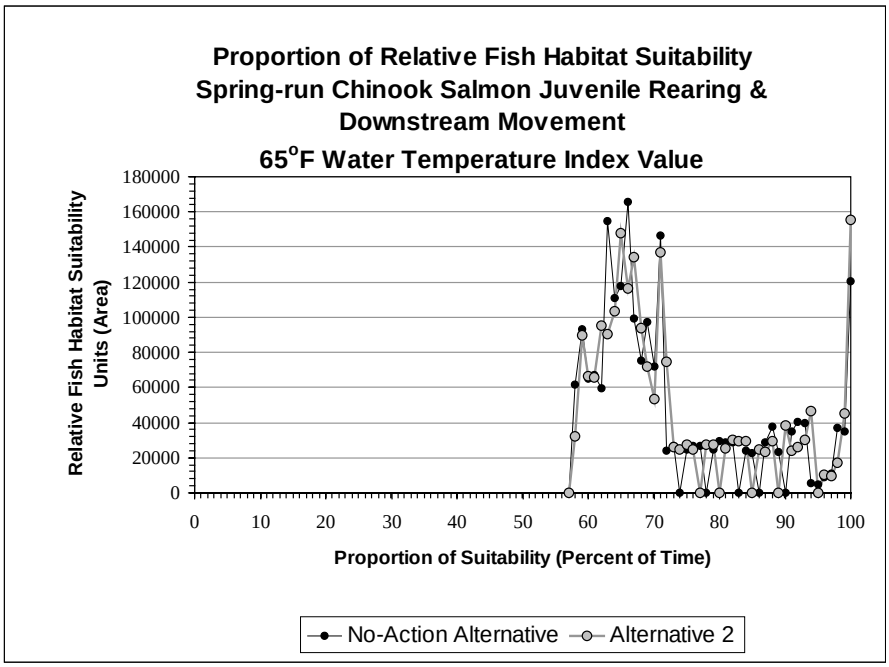

Figure G-AQUA5.4-20. Proportion of relative fish habitat suitability for spring-run Chinook salmon juvenile rearing and downstream movement for the 65°F water temperature index value.

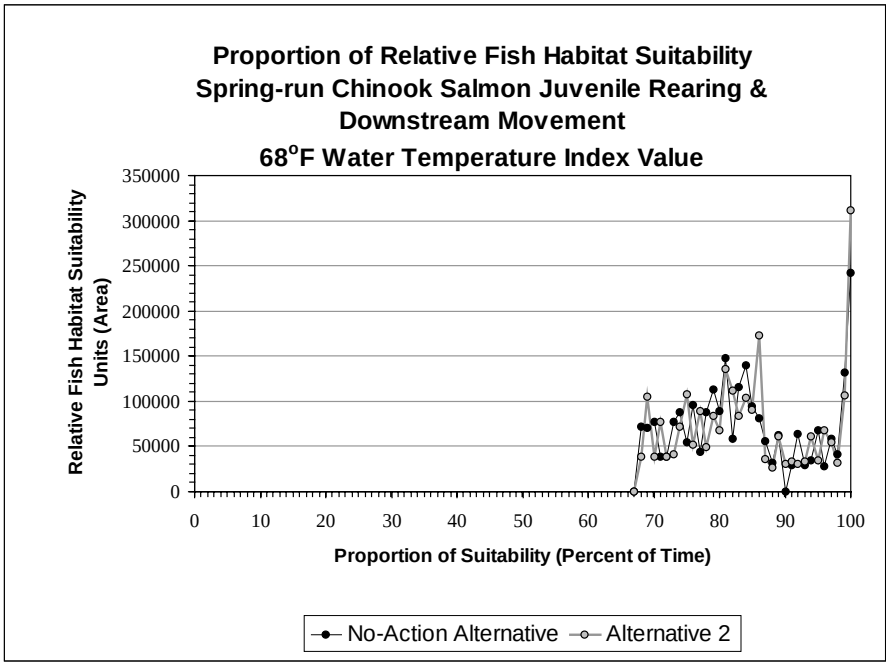

Figure G-AQUA5.4-21. Proportion of relative fish habitat suitability for spring-run Chinook salmon juvenile rearing and downstream movement for the 68°F water temperature index value.

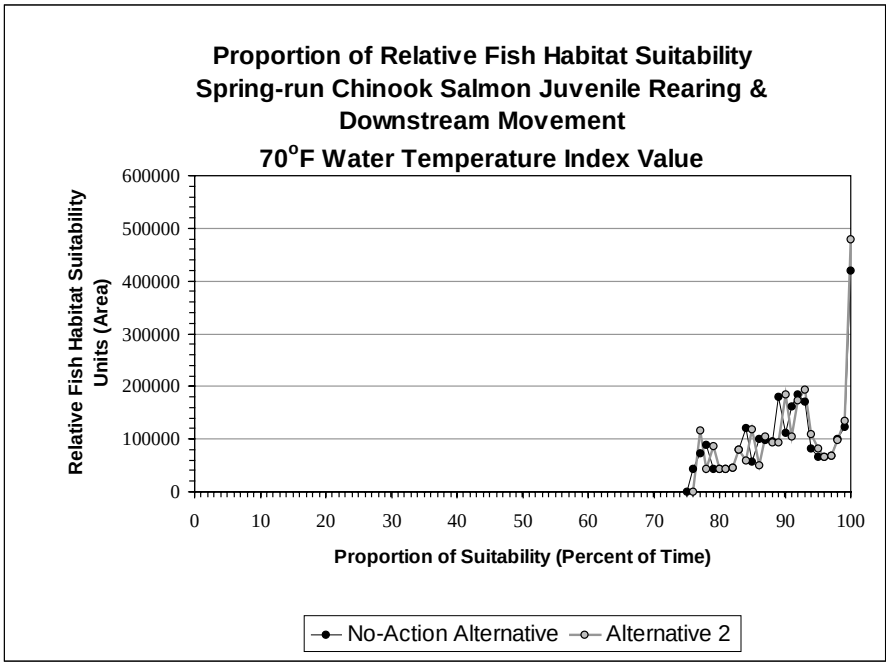

Figure G-AQUA5.4-22. Proportion of relative fish habitat suitability for spring-run Chinook salmon juvenile rearing and downstream movement for the 70°F water temperature index value.

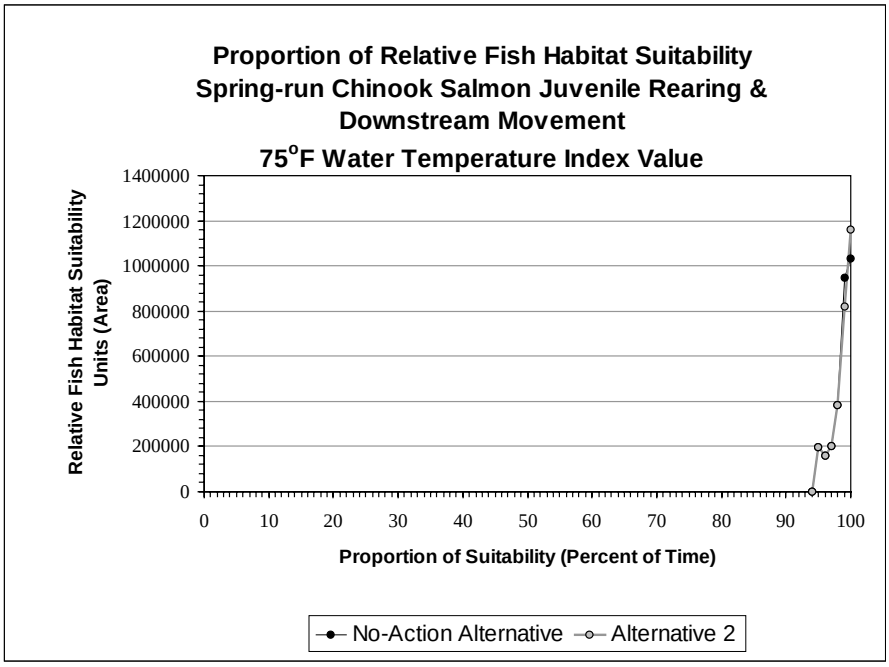

Figure G-AQUA5.4-23. Proportion of relative fish habitat suitability for spring-run Chinook salmon juvenile rearing and downstream movement for the 75°F water temperature index value.

The OHSIV metrics presented in Table G-AQUA5.4-5 for fall-run Chinook salmon juvenile rearing and downstream movement for the 60°F water temperature index value under the No-Action Alternative and Alternative 2 are 1,549,710 and 1,575,675, respectively. The difference in OHSIV between Alternative 2 and the No-Action Alternative is 25,965, which represents a 1.68 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative. The OHSIV for the 63°F water temperature index value under the No-Action Alternative and Alternative 2 are 1,870,208 and 1,894,221, respectively. The difference in OHSIV between Alternative 2 and the No-Action Alternative is 24,013, which represents a 1.28 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative. The OHSIV for the 65°F water temperature index value under the No-Action Alternative and Alternative 2 are 2,100,251 and 2,124,326, respectively. The difference in OHSIV between Alternative 2 and the No-Action Alternative is 24,075, which represents a 1.15 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative. The OHSIV for the 68°F water temperature index value under the No-Action Alternative and Alternative 2 are 2,460,196 and 2,478,520, respectively. The difference in OHSIV between Alternative 2 and the No-Action Alternative is 18,324, which represents a 0.74 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative. The OHSIV for the 70°F water temperature index value under the No-Action Alternative and Alternative 2 are 2,664,592 and 2,678,338, respectively. The difference in OHSIV between Alternative 2 and the No-Action Alternative is 13,746, which represents a 0.52 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative. The OHSIV for the 75°F water temperature index value under the No-Action Alternative and Alternative 2 are 2,916,561 and 2,917,860, respectively. The difference in OHSIV

Table G-AQUA5.4-5. Overall habitat suitability index value comparison between the No-Action Alternative and Alternative 2 for spring-run Chinook salmon juvenile rearing and downstream movement.

Water Temperature Index Value	60°F	63°F	65°F	68°F	70°F	75°F
No-Action Alternative						
Minimum Percentage of Time Value	44%	53%	58%	68%	76%	95%
Maximum Percentage of Time Value	96%	100%	100%	100%	100%	100%
Habitat Units at 100 Percent of Time	0	59,019	120,339	242,537	418,862	1,030,745
Percentage of Time at Maximum Habitat Units	47%	56%	66%	100%	100%	100%
OHSIV	1,549,710	1,870,208	2,100,251	2,460,196	2,664,592	2,916,561
Alternative 2						
Minimum Percentage of Time Value	44%	53%	58%	68%	77%	95%
Maximum Percentage of Time Value	96%	100%	100%	100%	100%	100%
Habitat Units at 100 Percent of Time	0	72,837	155,395	311,368	479,021	1,160,689
Percentage of Time at Maximum Habitat Units	47%	57%	100%	100%	100%	100%
OHSIV	1,575,675	1,894,221	2,124,326	2,478,520	2,678,338	2,917,860
Percent Change	1.68%	1.28%	1.15%	0.74%	0.52%	0.04%

between Alternative 2 and the No-Action Alternative is 1,299, which represents a 0.04 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative.

The Minimum Percentage of Time Value metric presented in Table G-AQUA5.4-5 for the spring-run Chinook salmon juvenile rearing and downstream movement life stage did not change between Alternative 2 and the No-Action Alternative for the 60°F, 63°F, 65°F, 68°F, or 75°F water temperature index values selected. The Minimum Percentage of Time Value metric for the 70°F water temperature index value under the No-Action Alternative and Alternative 2 are 76 percent and 77 percent, respectively. The 1 percent difference in Minimum Percentage of Time Value between Alternative 2 and the No-Action Alternative represents an increase in the number of habitat units with the smallest amount of time and area with water temperatures below 70°F under Alternative 2 compared to the No-Action Alternative.

The Maximum Percentage of Time Value metric presented in Table G-AQUA5.4-5 for the spring-run Chinook salmon juvenile rearing and downstream movement life stage did not change between Alternative 2 and the No-Action Alternative for any of the water temperature index values selected.

The Habitat Units at 100 Percent of Time metric presented in Table G-AQUA5.4-5 for the spring-run Chinook salmon juvenile rearing and downstream movement life stage did not change between Alternative 2 and the No-Action Alternative for the 60°F water temperature index value. The Habitat Units at 100 Percent of Time for the 63°F water temperature index value under the No-Action Alternative and Alternative 2 are 59,019 and 72,837, respectively. The difference in Habitat Units at 100 Percent of Time between Alternative 2 and the No-Action Alternative is 13,818, which represents approximately a 23 percent increase in the amount of habitat area under Alternative 2 compared to the No-Action Alternative in which water temperatures are always at or below 63°F. The Habitat Units at 100 Percent of Time for the 65°F water temperature index value under the No-Action Alternative and Alternative 2 are 120,339 and 155,395, respectively. The difference in Habitat Units at 100 Percent of Time between Alternative 2 and the No-Action Alternative is 35,056, which represents approximately a 29 percent increase in the amount of habitat area under Alternative 2 compared to the No-Action Alternative in which water temperatures are always at or below 65°F. The Habitat Units at 100 Percent of Time for the 68°F water temperature index value under the No-Action Alternative and Alternative 2 are 224,537 and 311,368, respectively. The difference in Habitat Units at 100 Percent of Time between Alternative 2 and the No-Action Alternative is 68,831, which represents approximately a 28 percent increase in the amount of habitat area under Alternative 2 compared to the No-Action Alternative in which water temperatures are always at or below 68°F. The Habitat Units at 100 Percent of Time for the 70°F water temperature index value under the No-Action Alternative and Alternative 2 are 418,862 and 479,021, respectively. The difference in Habitat Units at 100 Percent of Time between Alternative 2 and the No-Action Alternative is 60,159, which represents approximately a 14 percent increase in the amount of habitat area under Alternative 2 compared to the No-Action Alternative in which water temperatures are always at or below 70°F. The Habitat Units at 100 Percent of Time for the 75°F water temperature index value under the No-Action Alternative and Alternative 2 are 1,030,745 and 1,160,689, respectively. The difference in Habitat Units at 100 Percent of Time between Alternative 2 and the No-Action Alternative is 129,944, which represents approximately a 13 percent increase in the amount of habitat area under Alternative 2 compared to the No-Action Alternative in which water temperatures are always at or below 75°F.

A 23 percent increase in the number of habitat units in which water temperatures are always at or below 63°F and above 60°F represents an increase in habitat under Alternative 2 in which specific biological effects could potentially occur to rearing and downstream migrating juvenile spring-run Chinook salmon, such as such as acceleration or inhibition of smoltification, and decreased feeding and growth rates, (Clarke and Shelbourn 1985; Marine 1997; Zedonis and Newcomb 1997). A 29 percent increase in the number of habitat units in which water temperatures are always at or below 65°F and above 63°F represents an increase in habitat under Alternative 2 in which specific biological effects could potentially occur to rearing and downstream migrating juvenile spring-run Chinook salmon, such as acceleration or inhibition of smoltification, decreased growth rates, and increased susceptibility to disease (Clarke and Shelbourn 1985; Marine 1997; Ordal and Pacha 1963; Zedonis and Newcomb

1997). A 28 percent increase in the number of habitat units in which water temperatures are always at or below 68°F and above 65°F represents an increase in habitat under Alternative 2 in which specific biological effects could potentially occur to rearing and downstream migrating juvenile spring-run Chinook salmon, such as acceleration or inhibition of smoltification, decreased growth rates, increased stress response, decreased metabolic efficiency, and increased mortality rates (Brett et al. 1982; Clarke and Shelbourn 1985; Independent Scientific Group 1996; Marine 1997; Ordal and Pacha 1963; Zedonis and Newcomb 1997). A 14 percent increase in the number of habitat units in which water temperatures are always at or below 70°F and above 68°F represents an increase in habitat under Alternative 2 in which specific biological effects could potentially occur to rearing and downstream migrating juvenile spring-run Chinook salmon, such as increased incidence of disease, hyperactivity, decreased appetite, reduced growth rates, and increased mortality rates (McCullough 1999; Rich 1987). A 13 percent increase in the number of habitat units in which water temperatures are always at or below 75°F and above 70°F represents an increase in habitat under Alternative 2 in which specific biological effects could potentially occur to rearing and downstream migrating juvenile spring-run Chinook salmon, such as substantially increased incidence of disease, hyperactivity, decreased appetite, reduced growth rates, and substantially increased mortality rates (McCullough 1999; Rich 1987). A detailed description of the potential effects that could occur to rearing and downstream migrating juvenile spring-run Chinook salmon from exposure to water temperatures above each water temperature index value is presented in Section G-AQUA2.2.3 of Appendix G-AQUA2.

The Percentage of Time at Maximum Habitat Units metric presented in Table G-AQUA5.4-5 for the spring-run Chinook salmon juvenile rearing and downstream movement life stage did not change between Alternative 2 and the No-Action Alternative for the 60°F, 68°F, 70°F or the 75°F water temperature index values. The Percentage of Time at Maximum Habitat Units presented in Table G-AQUA5.4-5 for the spring-run Chinook salmon juvenile rearing and downstream movement life stage for the 63°F water temperature index value under the No-Action Alternative and Alternative 2 are 56 percent and 57 percent, respectively. The difference in Percentage of Time at Maximum Habitat Units between Alternative 2 and the No-Action Alternative is 1 percent, which represents a small increase in the percentage of time that the habitat is suitable in the greatest area. The Percentage of Time at Maximum Habitat Units presented in Table G-AQUA5.4-5 for the spring-run Chinook salmon juvenile rearing and downstream movement life stage for the 65°F water temperature index value under the No-Action Alternative and Alternative 2 are 66 percent and 100 percent, respectively. The difference in Percentage of Time at Maximum Habitat Units between Alternative 2 and the No-Action Alternative is 34 percent, which represents an increase in the percentage of time that the habitat is suitable in the greatest area.

G-AQUA5.4.2.3 Predation-related Effects

Changes in minimum flows in the Low Flow Channel are not expected to change the nature or rate of predation with implementation of Alternative 2. Water temperature changes would be very small and are not expected to change the distribution, species

composition, consumption rates, or nature of predation in the lower Feather River. Adaptive management changes in steelhead hatchery release practices may reduce predation of juvenile spring-run Chinook salmon. The Large Woody Debris Supplementation and Improvement Program would improve juvenile rearing cover conditions and may result in a reduction of predation rates on juvenile spring-run Chinook salmon.

G-AQUA5.4.2.4 Fisheries Management–related Effects

Hatchery

The Hatchery Adaptive Management Program included in Alternative 2 is the same as that included in the Proposed Action, with the exception of the inclusion of a water treatment facility for the hatchery water supply. See Section G-AQUA4.4 of Appendix G-AQUA4, Effects of the Proposed Action, for an evaluation of the Hatchery Adaptive Management Program. The proposed hatchery water treatment could reduce the rate of incidence and severity of disease occurrences in the Feather River Fish Hatchery, which, as a result, would lower contributions of the accumulated disease pressure in the lower Feather River.

Disease

Water temperature changes with implementation of Alternative 2 would be relatively small; therefore, no changes in water temperature–related interactions with the incidence of fish diseases are anticipated. The proposed hatchery water treatment could reduce the rate of incidence and severity of disease occurrences in the Feather River Fish Hatchery, which, as a result, would lower contributions of the accumulated disease pressure in the lower Feather River.

Fishing Regulations, Poaching, and Change in Recreational Access and Visitation

Section 5.10.2, Recreation Resources Environmental Effects, forecasts a one-third increase in recreation and angling activities with the No-Action Alternative and an approximately 51 percent increase in recreation and angling under Alternative 2 as compared to the existing condition. This would indicate an expected increase of approximately 18 percent in recreation and angling under Alternative 2 compared to the No-Action Alternative. A 18 percent increase in angling with no other fisheries changes would equate to increased angler harvest rates. Fishing access would be increased under Alternative 2 with the implementation of several recreation facilities on the lower Feather River. (See Section 5.10.2.3 for additional information on recreation facilities and changes in visitation under Alternative 2.) No fishing zones in proximity to the fish barrier weirs included in Alternative 2 will change the fishing regulations under Alternative 2.

G-AQUA5.4.2.5 Summary of Potential Effects on Spring-run Chinook Salmon

Study plan report summaries addressing project effects on spring-run Chinook salmon are presented in Section G-AQUA1.5, Fisheries Management; Section G-AQUA1.8, Salmonids and Their Habitat in the Feather River Below the Fish Barrier Dam; Section G-AQUA1.10, Instream Flows and Fish Habitat and Section G-AQUA1.11, Predation, of Appendix G-AQUA1, Affected Environment. A description of each spring-run Chinook salmon life stage and the time period associated with it is presented in Appendix G-AQUA1.

Effects on spring-run Chinook salmon associated with installation of fish barrier weirs, the Large Woody Debris Supplementation and Improvement Program, and the Gravel Supplementation and Improvement Program with implementation of Alternative 2 would not differ from those effects associated with the Proposed Action; relative to the No-Action Alternative. Appendix G-AQUA4, Effects of the Proposed Action, describes the effects associated with each PM&E measure proposed for implementation under the Proposed Action. Additionally, water temperature–related effects resulting from changes in flows in the Low Flow Channel under Alternative 2 are not expected to alter disease or predation effects because the changes in water temperature compared to the No-Action Alternative would be small.

Adult Immigration and Holding

Actions potentially affecting spring-run Chinook salmon adult immigration and holding include changes to instream flows and water temperatures in the Low Flow Channel. Creation and enhancement of side-channel habitat and a Hatchery Adaptive Management Program implemented under Alternative 2 would differ slightly from those PM&E measures proposed for implementation under the Proposed Action, but would have the same types of effects on spring-run Chinook salmon adult immigration and holding as compared to the No-Action Alternative. Appendix G-AQUA4, Effects of the Proposed Action, describes the effects associated with each PM&E measure proposed for implementation under the Proposed Action.

An increased instream flow of 800 cfs in the Low Flow Channel under Alternative 2 could potentially have a beneficial effect on immigrating and holding spring-run Chinook salmon by increasing lower Feather River stage elevations. Although stage increases would be small, shallow riffles could potentially become deeper, reducing the effort required by immigrating adult spring-run Chinook salmon to proceed through shallow riffles. Water depth also would be increased, creating additional amounts of suitable holding habitat related to water depths. Reduced average daily water temperatures during the spring-run Chinook salmon adult immigration and holding period, result in increased overall habitat suitability for each water temperature index value.

Overall, implementation of Alternative 2 would result in a beneficial effect on spring-run Chinook salmon adult immigration and holding.

Adult Spawning and Embryo Incubation

Actions potentially affecting spring-run Chinook salmon adult spawning and embryo incubation include a Hatchery Adaptive Management Program, creation and enhancement of side-channel habitat, and instream flow and water temperature changes in the Low Flow Channel.

Many of the effects of a Hatchery Adaptive Management Program would be the same as those identified for the Proposed Action (Appendix G-AQUA4), relative to the No-Action Alternative, with one exception. The water treatment program associated with the Hatchery Adaptive Management Program under Alternative 2 would potentially have an additional beneficial effect on incubating spring-run Chinook salmon embryos by minimizing the potential for disease-associated embryonic mortality in the Feather River Fish Hatchery and by reducing the accumulated disease pressure in the lower Feather River.

Creation and enhancement of side-channel habitat under Alternative 2 would provide an additional benefit over the Proposed Action as compared to the No-Action Alternative because there would be a greater area of side-channel habitat under Alternative 2.

An increase in instream flow in the Low Flow Channel from 600 cfs to 800 cfs during the adult spawning and embryo incubation period would increase the amount of available spawning habitat from a PHABSIM WUA from 91 percent of maximum to almost 100 percent of maximum. Additionally, during extreme drought years, decreases in flow from 800 cfs to 750 cfs likely would not affect spring-run Chinook salmon adult spawning and embryo incubation because 750 cfs represents approximately 99 percent of maximum WUA, while 800 cfs represents almost 100 percent of maximum WUA. Reduce average daily water temperatures under Alternative 2 result in increased overall habitat suitability for each water temperature index value for spring-run Chinook salmon adult spawning and embryo incubation.

Overall, implementation of Alternative 2 would result in a beneficial effect on spring-run Chinook salmon adult spawning and embryo incubation.

Juvenile Rearing and Downstream Movement

Actions potentially affecting spring-run Chinook salmon juvenile rearing and downstream movement include a Hatchery Adaptive Management Program, side-channel habitat enhancement and creation, and changes to instream flows and water temperatures in the Low Flow Channel. Many of the effects of a Hatchery Adaptive Management Program would be the same as those identified for the Proposed Action (Appendix G-AQUA4), relative to the No-Action Alternative, with one exception. The water treatment program associated with the Hatchery Adaptive Management Program under Alternative 2 would potentially have an additional beneficial effect on rearing spring-run Chinook salmon juveniles by minimizing the potential for disease-associated mortality in the Feather River Fish Hatchery and by reducing the accumulated disease pressure in the lower Feather River.

Creation and enhancement of side-channel habitat under Alternative 2 would provide an additional benefit over the Proposed Action as compared to the No-Action Alternative because there would be an increased quantity and quality of side-channel habitat under Alternative 2.

Flow fluctuations ranging from 800 cfs to 1,200 cfs in the Low Flow Channel could occur from May 1 through June 15 when total releases up to 1,200 cfs are routed through the Low Flow Channel. This could result in an adverse effect on spring-run Chinook salmon juvenile rearing and downstream movement by increasing the potential for beach stranding. Based on the emigration timing of most juvenile Chinook salmon in the Feather River, and on the preference for increased water depths as rearing juveniles grow larger later in the rearing season, it is unlikely that any substantial change in the rate of beach stranding would occur as a result of flow fluctuations in the Low Flow Channel from May 1 through June 15. Temperature control changes in flow from 800 cfs to approximately 1,000 cfs later in the summer season would also not be expected to result in beach stranding of juvenile spring-run Chinook salmon. Additionally, increased flows would slightly reduce average daily water temperatures during the juvenile rearing and downstream movement period for spring-run Chinook salmon, resulting in increased overall habitat suitability for the 60°F, 63°F, and 65°F water temperature index values. However, model results indicate that differences in habitat suitability due to decreased water temperatures for the remaining water temperature index values are less than 1 percent between the No-Action Alternative and Alternative 2, and as such, are considered below the detection limits of the analytical tools utilized in the habitat suitability analysis.

Overall, implementation of Alternative 2 would result in a beneficial effect on spring-run Chinook salmon juvenile rearing and downstream movement.

Conclusion

Under Alternative 2, flows and flow fluctuations occurring in the High Flow Channel are not expected to differ from those occurring under the No-Action Alternative (described in Section 5.4.2.1). Therefore, Alternative 2 would not result in a flow-related change in the quality, quantity, or distribution of spring-run Chinook salmon habitat occurring in the High Flow Channel. Flow increases in the Low Flow Channel and water temperature reductions also benefit the spring-run Chinook habitat quality and quantity. Habitat improvement programs including side-channel creation and enhancement and the Gravel Supplementation and Improvement Program and Large Woody Debris Supplementation and Improvement Program also would be beneficial for spring-run Chinook salmon habitat quality and quantity.

Based on the above summary of potential effects, it is likely that implementation of Alternative 2 would result in an overall beneficial effect on spring-run Chinook salmon.

G-AQUA5.4.3 Steelhead

G-AQUA5.4.3.1 Flow-related Effects

Adult Immigration and Holding

Flow in the High Flow Channel would not change with implementation of Alternative 2, relative to the No-Action Alternative; therefore, there would be no flow-related effects on steelhead adult immigration and holding in the High Flow Channel. Water depths in the Low Flow Channel would be increased slightly with implementation of Alternative 2, which would be slightly beneficial to steelhead adult immigration and holding because of the increase in amount of habitat that would meet minimum water depth requirements. Increased flows in the Low Flow Channel from May through June 15 would have no effect on steelhead adult immigration and holding because the adult immigration and holding period for adult steelhead migrating to the Feather River begins in September.

Adult Spawning and Embryo Incubation

Under Alternative 2, flow in the Low Flow Channel would be 800 cfs year-round, except from May 1 through June 15, when the total releases from the Oroville Facilities would be released down the Low Flow Channel, up to a maximum flow of 1,200 cfs. Flow fluctuations in the Low Flow Channel from 800 to 1,200 cfs from May 1 through June 15, and from 800 to 1,000 cfs for water temperature control during in the summer, could potentially occur with implementation of Alternative 2.

No flow increases above 800 cfs would occur before the end of steelhead spawning; therefore, there would be no risk of establishing redds at stage elevations that could potentially be dewatered by a subsequent Low Flow Channel flow fluctuation.

Implementation of Alternative 2 would not result in any change in the frequency or magnitude of flow fluctuations in the High Flow Channel relative to the No-Action Alternative; therefore, there would be no change in the rate of steelhead redd dewatering occurring in the High Flow Channel with implementation of Alternative 2.

Evaluation of the WUA index generated by the PHABSIM model for the steelhead adult spawning life stage indicates the maximum amount of spawning area in the Low Flow Channel, given the current channel configuration, occurs at flows around 500 cfs. However, no distinct maximum occurs over the range of flow between 150 cfs and 1,500 cfs. Figure G-AQUA5.4-24 shows the steelhead spawning WUA curve (lower) generated by the PHABSIM model for the Low Flow Channel.

Under the No-Action Alternative, flows in the Low Flow Channel during the steelhead spawning period would be 600 cfs, which would result in approximately 98 percent of maximum WUA. Flows in the Low Flow Channel under Alternative 2 would be 800 cfs during the steelhead spawning period, which would result in approximately 91 percent of maximum WUA, representing a decrease in WUA compared to the No-Action Alternative.

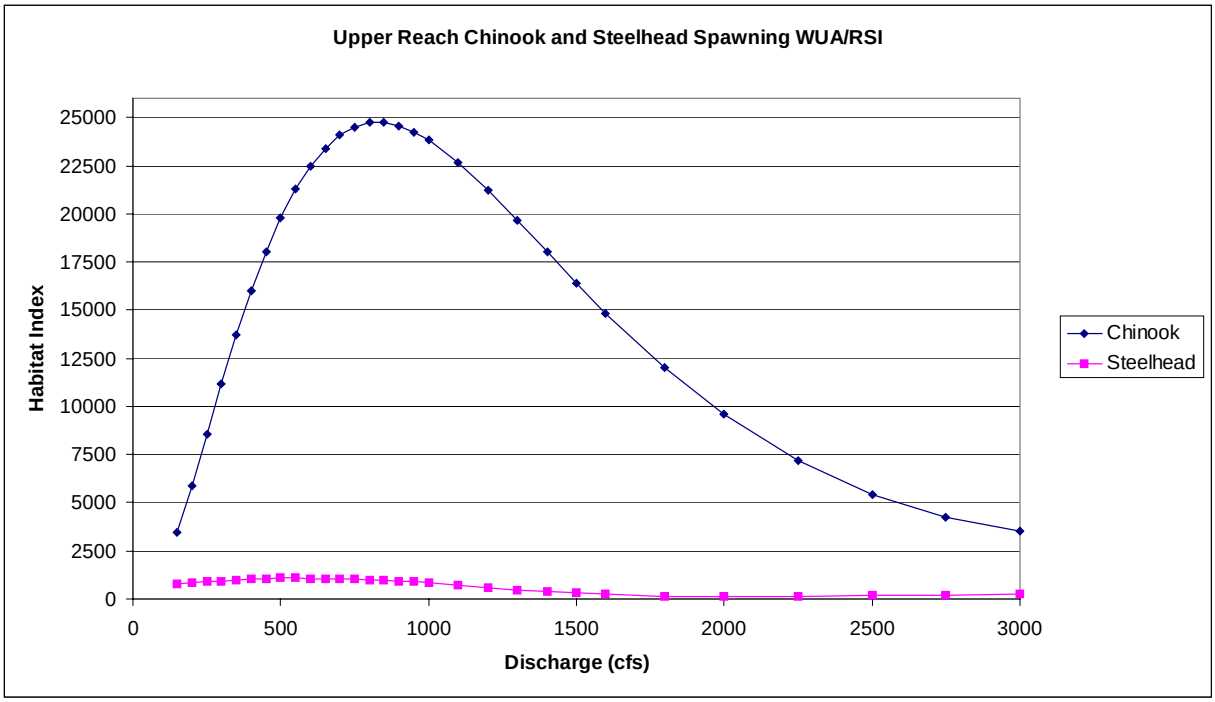

Figure G-AQUA5.4-24. Low Flow Channel WUA curves for steelhead and Chinook salmon.

Under Alternative 2, flows and flow fluctuations occurring in the High Flow Channel are not expected to differ from those occurring under the No-Action Alternative (described in Section 5.4.2.1, Water Quantity Environmental Effects). As a result, implementation of Alternative 2 would not result in a change in the amount of steelhead spawning habitat available or rates of redd dewatering occurring in the High Flow Channel.

Fry and Fingerling Rearing and Downstream Movement

Flow fluctuations in the Low Flow Channel could potentially occur under Alternative 2 to meet water temperature objectives prescribed to protect fisheries resources, or through change in total releases occurring between 800 and 1,200 cfs from May 1 through June 15. Under Alternative 2, the maximum normal operation flow fluctuations in the Low Flow Channel would be 400 cfs. Flow fluctuations can result in juvenile salmonid stranding in isolation ponds or beach stranding. Isolation ponds do not occur in the Low Flow Channel below 1,200 cfs; therefore, no isolation pond–type stranding would be anticipated with implementation of Alternative 2. Beach stranding can occur with changes in water surface elevation from changes in flows. Juvenile steelhead tend to select deeper water with increased size and become less susceptible to beach-type stranding as they grow later in the juvenile rearing period. Flow fluctuations in the Low Flow Channel with implementation of Alternative 2 would occur from May 1 through June 15, with a maximum flow fluctuation of 400 cfs. Flow fluctuations of typically 200 cfs or less also would occur during the summer as a result of temperature control actions. The May 1 through June 15 flow fluctuations of up to 400 cfs likely would result in some occurrences of steelhead beach stranding during this time period. After June

15, water temperature control-related flow changes are typically 200 cfs or less and occur when rearing juveniles are larger and have preference for deeper water, and therefore are not susceptible to beach-type stranding from water temperature control-related flow changes.

Implementation of Alternative 2 would not result in any change in the frequency or magnitude of flow fluctuations in the High Flow Channel compared to the No-Action Alternative; therefore, there would be no change in the rate of juvenile steelhead stranding occurring in the High Flow Channel.

Smolt Emigration

Changes in Low Flow Channel flows with implementation of Alternative 2 are not expected to affect the quality or quantity of habitat for steelhead smolt emigration or the timing behavior of smolt emigration because emigrating smolts spend little time foraging and rearing and the majority of time actively migrating seaward.

G-AQUA5.4.3.2 Temperature-related Effects

The relative habitat suitability analysis includes an evaluation of overall relative habitat suitability based on water temperature index values. The analysis includes a comparison of habitat suitability component metrics between the No-Action Alternative and Alternative 2. The OHSIV analysis is described in the above discussion of temperature-related effects on fall-run Chinook salmon. Detailed descriptions of the methodology used in the derivation and calculation of each of the above metrics are presented in Section G-AQUA.2.2.3 of Appendix G-AQUA2, Methodology.

Adult Immigration and Holding

Figures G-AQUA5.4-25, G-AQUA5.4-26, and G-AQUA5.4-27 show the proportion of time that habitat units are considered suitable for each water temperature index value selected. The area under each curve displayed in Figures G-AQUA5.4-25, G-AQUA5.4-26, and G-AQUA5.4-27 is equal, which allows for direct comparison of habitat suitability between alternatives.

The OHSIV metrics presented in Table G-AQUA5.4-6 for steelhead adult immigration and holding for the 52°F water temperature index value under the No-Action Alternative and Alternative 2 are 1,100,514 and 1,098,088, respectively. The difference in OHSIV between the No-Action Alternative and Alternative 2 is 2,425, which represents a 0.22 percent decrease in OHSIV under Alternative 2 compared to the No-Action Alternative. The OHSIV for the 56°F water temperature index value under the No-Action Alternative and Alternative 2 are 1,712,352 and 1,734,439, respectively. The difference in OHSIV between Alternative 2 and the No-Action Alternative is 22,087, which represents a 1.29 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative. The OHSIV for the 70°F water temperature index value under the No-Action Alternative and Alternative 2 are 2,836,131 and 2,845,249, respectively. The difference in OHSIV

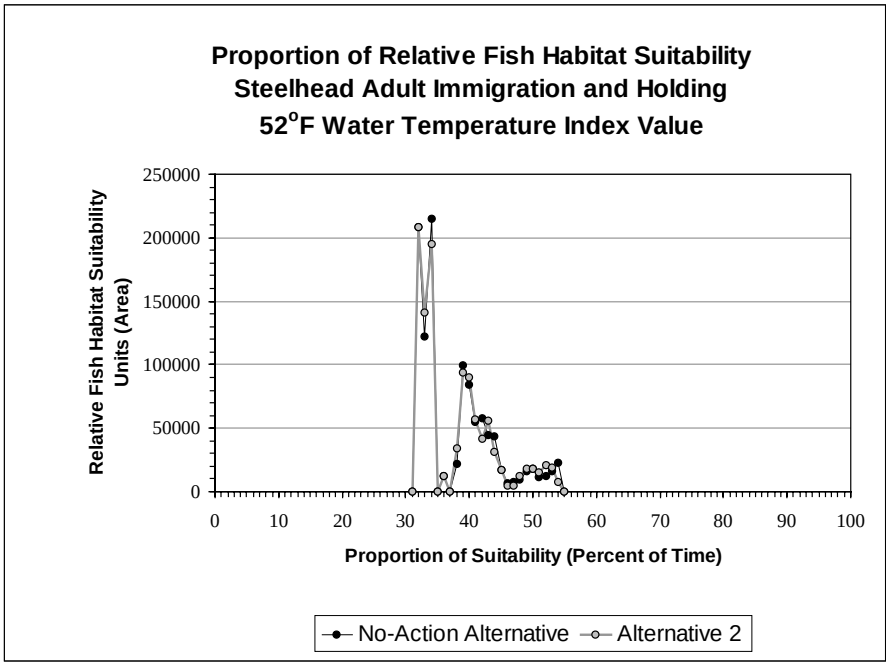

Figure G-AQUA5.4-25. Proportion of relative fish habitat suitability for steelhead adult immigration and holding for the 52°F water temperature index value.

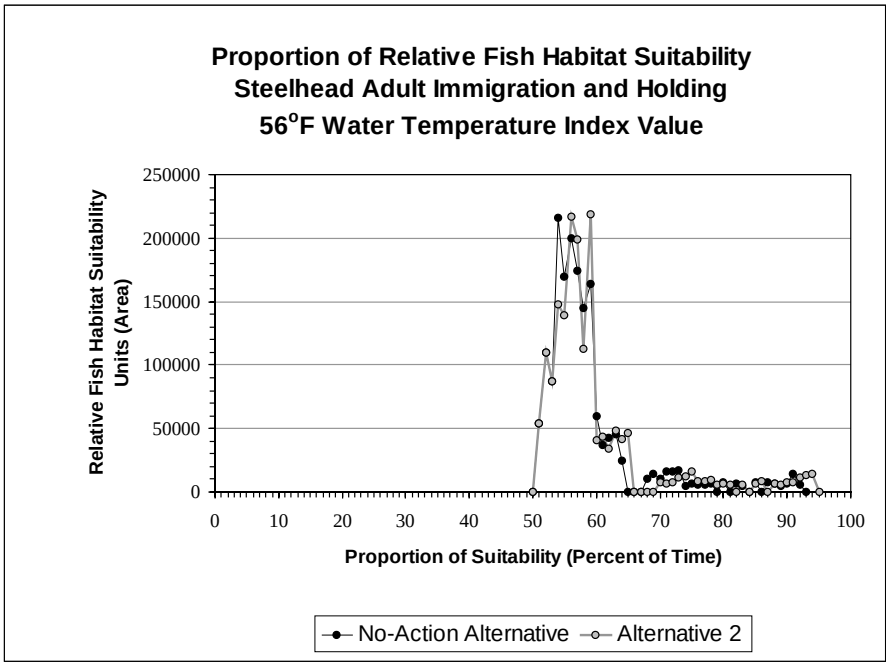

Figure G-AQUA5.4-26. Proportion of relative fish habitat suitability for steelhead adult immigration and holding for the 56°F water temperature index value.

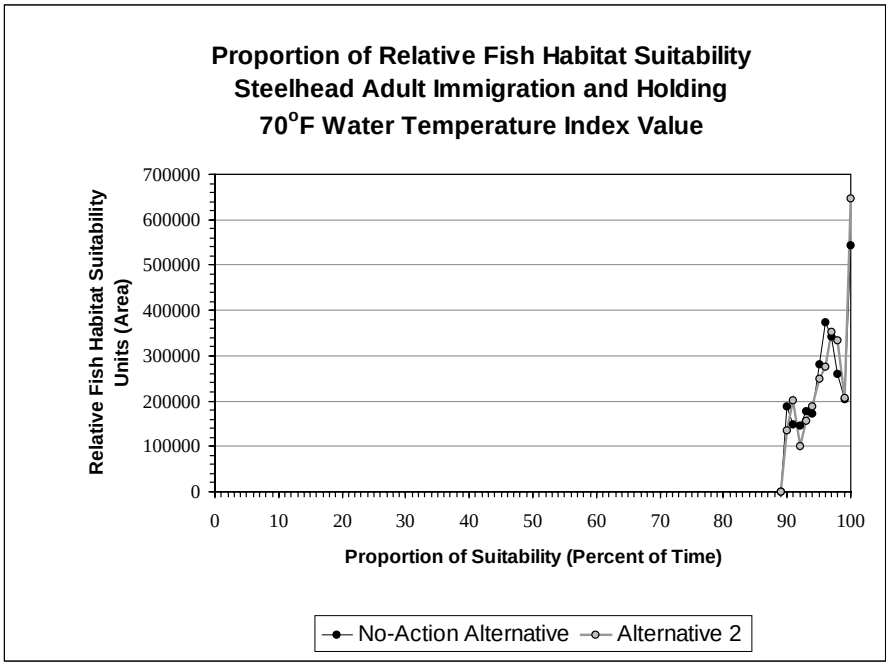

Figure G-AQUA5.4-27. Proportion of relative fish habitat suitability for steelhead adult immigration and holding for the 70°F water temperature index value.

Table G-AQUA5.4-6. Overall habitat suitability index value comparison between the No-Action Alternative and Alternative 2 for steelhead adult immigration and holding.

Water Temperature Index Value	52°F	56°F	70°F
No-Action Alternative			
Minimum Percentage of Time Value	32%	51%	90%
Maximum Percentage of Time Value	54%	92%	100%
Habitat Units at 100 Percent of Time	0	0	542,986
Percentage of Time at Maximum Habitat Units	34%	54%	100%
OHSIV	1,100,514	1,712,352	2,836,131
Alternative 2			
Minimum Percentage of Time Value	32%	51%	90%
Maximum Percentage of Time Value	54%	94%	100%
Habitat Units at 100 Percent of Time	0	0	646,443
Percentage of Time at Maximum Habitat Units	32%	59%	100%
OHSIV	1,098,088	1,734,439	2,845,249
Percent Change	**-0.22%**	**1.29%**	**0.32%**

between Alternative 2 and the No-Action Alternative is 9,118, which represents a 0.32 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative.

The Minimum Percentage of Time Value metric presented in Table G-AQUA5.4-6 for the steelhead adult immigration and holding life stage did not change between Alternative 2 and the No-Action Alternative for any of the water temperature index values selected.

The Maximum Percentage of Time Value metric presented in Table G-AQUA5.4-6 for the steelhead adult immigration and holding life stage did not change between the No -Action Alternative and existing conditions for the 52°F or 70°F water temperature index values. The Maximum Percentage of Time Value metric for the 56°F water temperature index value under the No-Action Alternative and Alternative 2 are 92 percent and 94 percent, respectively. The two percent difference in Maximum Percentage of Time Value between Alternative 2 and the No-Action Alternative represents a small increase in the number of habitat units with the greatest amount of time and area with water temperatures below 56°F under Alternative 2 compared to the No-Action Alternative.

The Habitat Units at 100 Percent of Time metric presented in Table G-AQUA5.4-6 for the steelhead adult immigration and holding life stage did not change between Alternative 2 and the No -Action Alternative for the 52°F or 56°F water temperature index values. The Habitat Units at 100 Percent of Time for the 70°F water temperature index value under the No-Action Alternative and Alternative 2 are 542,986 and 646,443, respectively. The difference in Habitat Units at 100 Percent of Time between Alternative 2 and the No-Action Alternative is 103,457, which represents approximately a 19 percent increase in the amount of habitat area under Alternative 2 compared to the No-Action Alternative in which water temperatures are always at or below 70°F.

A 19 percent increase in the number of habitat units in which water temperatures are always at or below 70°F and above 56°F represents an increase in habitat under Alternative 2 in which specific biological effects could potentially occur to immigrating and holding steelhead, such as cessation of immigration, decreased spawning success, and decreased in vivo egg viability (Bruin and Waldsdorf 1975; McCullough et al. 2001).

The Percentage of Time at Maximum Habitat Units metric presented in Table G-AQUA5.4-6 for the steelhead adult immigration and holding life stage did not change between Alternative 2 and the No -Action Alternative for the 70°F water temperature index value. The Percentage of Time at Maximum Habitat Units metric presented for the steelhead adult immigration and holding life stage for the 52°F water temperature index value under the No-Action Alternative and Alternative 2 are 34 percent and 32 percent, respectively. The difference in Percentage of Time at Maximum Habitat Units between the No-Action Alternative and Alternative 2 is two percent, which represents a decrease in the percentage of time that the habitat is suitable in the greatest area under Alternative 2. The Percentage of Time at Maximum Habitat Units metric presented for the steelhead adult immigration and holding life stage for the 56°F water temperature index value under the No-Action Alternative and Alternative 2 are 54 percent and 59 percent, respectively. The difference in Percentage of Time at Maximum Habitat Units

between Alternative 2 and the No-Action Alternative is five percent, which represents an increase in the percentage of time that the habitat is suitable in the greatest area.

Adult Spawning and Embryo Incubation

Figures G-AQUA5.4-28, G-AQUA5.4-29, G-AQUA5.4-30, and G-AQUA5.4-31 show the proportion of time that habitat units are considered suitable for each water temperature index value selected. The area under each curve displayed in Figures G-AQUA5.4-28, G-AQUA5.4-29, G-AQUA5.4-30, and G-AQUA5.4-31 is equal, which allows for direct comparison of habitat suitability between alternatives.

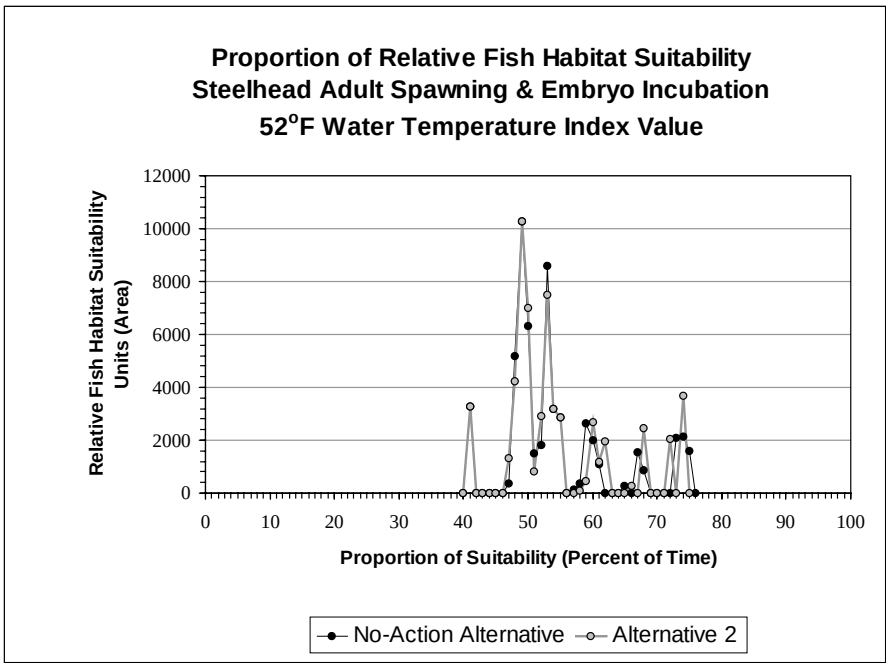

Figure G-AQUA5.4-28. Proportion of relative fish habitat suitability for steelhead adult spawning and embryo incubation for the 52°F water temperature index value.

The OHSIV metrics presented in Table G-AQUA5.4-7 for steelhead adult spawning and embryo incubation for the 52°F water temperature index value under the No-Action Alternative and Alternative 2 are 58,198 and 58,242, respectively. The difference in OHSIV between Alternative 2 and the No-Action Alternative is 44, which represents a 0.08 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative. The OHSIV for the 54°F water temperature index value under the No-Action Alternative and Alternative 2 are 71,613 and 72,759, respectively. The difference in OHSIV between Alternative 2 and the No-Action Alternative is 1,164, which represents a 1.60 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative. The OHSIV for the 57°F water temperature index value under the No-Action Alternative and Alternative 2 are 87,172 and 88,550, respectively. The difference in OHSIV between Alternative 2 and the No-Action Alternative is 1,378, which represents a 1.58 percent increase in OHSIV under Alternative 2 compared to the

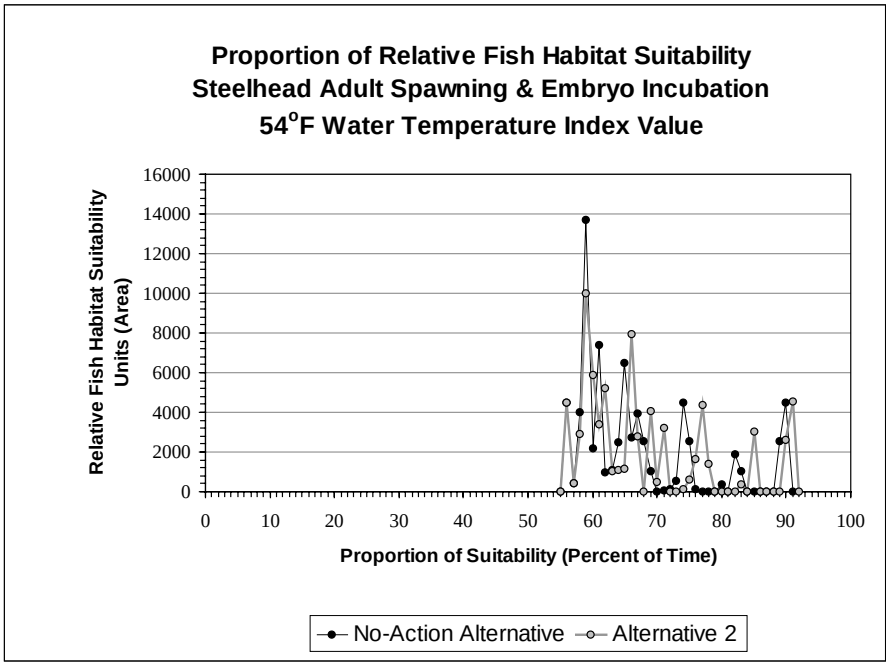

Figure G-AQUA5.4-29. Proportion of relative fish habitat suitability for steelhead adult spawning and embryo incubation for the 54°F water temperature index value.

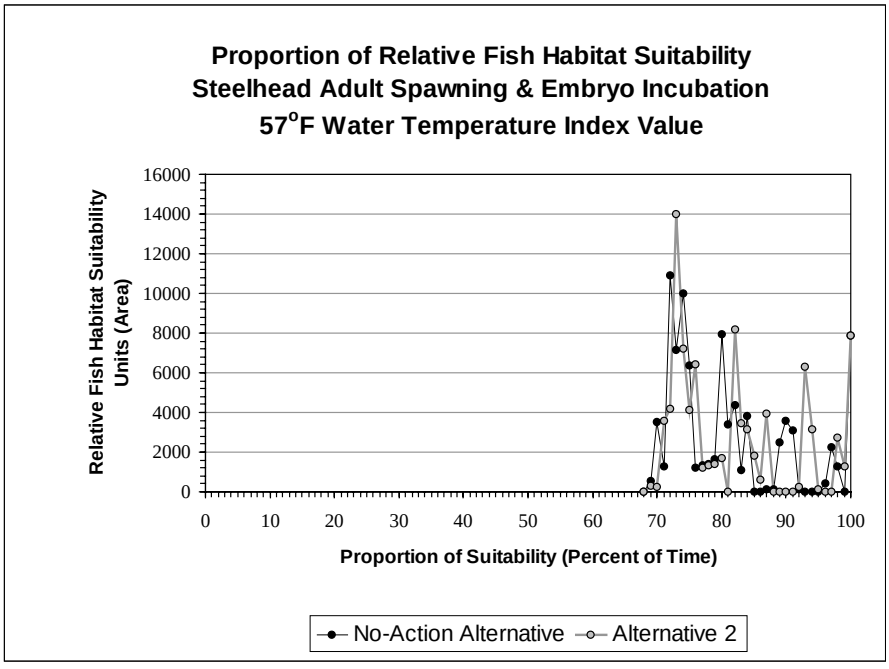

Figure G-AQUA5.4-30. Proportion of relative fish habitat suitability for steelhead adult spawning and embryo incubation for the 57°F water temperature index value.

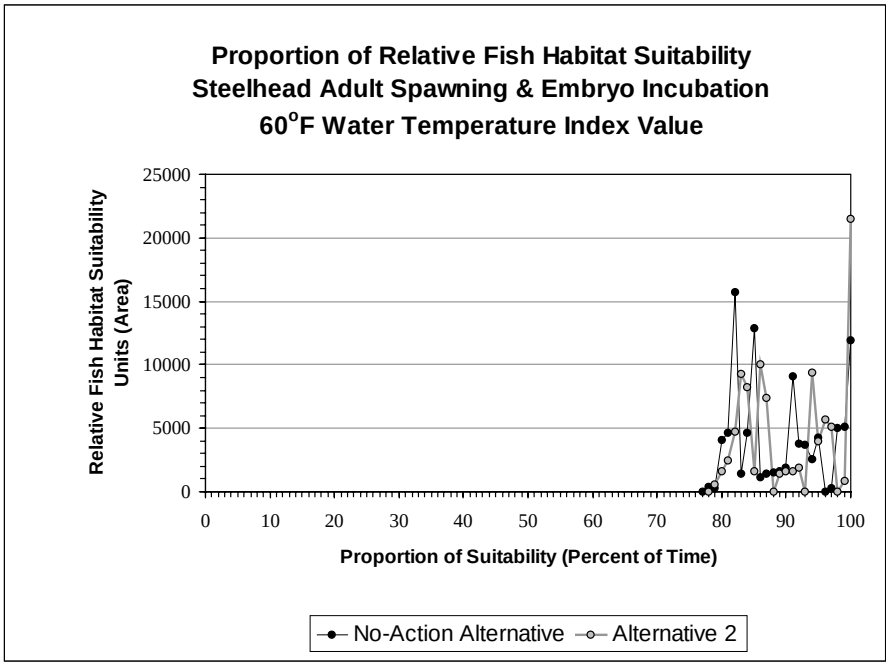

Figure G-AQUA5.4-31. Proportion of relative fish habitat suitability for steelhead adult spawning and embryo incubation for the 60°F water temperature index value.

Table G-AQUA5.4-7. Overall habitat suitability index value comparison between the No-Action Alternative and Alternative 2 for steelhead adult spawning and embryo incubation.

Water Temperature Index Value	52°F	54°F	57°F	60°F
No-Action Alternative				
Minimum Percentage of Time Value	41%	56%	69%	78%
Maximum Percentage of Time Value	75%	90%	100%	100%
Habitat Units at 100 Percent of Time	0	0	7,858	11,890
Percentage of Time at Maximum Habitat Units	49%	59%	72%	82%
OHSIV	58,198	71,613	87,172	97,181
Alternative 2				
Minimum Percentage of Time Value	41%	56%	69%	79%
Maximum Percentage of Time Value	74%	91%	100%	100%
Habitat Units at 100 Percent of Time	0	0	7,858	21,526
Percentage of Time at Maximum Habitat Units	49%	59%	73%	100%
OHSIV	58,242	72,759	88,550	98,881
Percent Change	0.08%	1.60%	1.58%	1.75%

No-Action Alternative. The OHSIV for the 60°F water temperature index value under the No-Action Alternative and Alternative 2 are 97,181 and 98,881, respectively. The difference in OHSIV between Alternative 2 and the No-Action Alternative is 1,701, which represents a 1.75 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative.

The Minimum Percentage of Time Value metric presented in Table G-AQUA5.4-7 for the steelhead adult spawning and embryo incubation life stage did not change between Alternative 2 and the No-Action Alternative for the 52°F, 54°F, and 57°F water temperature index values. The Minimum Percentage of Time Value metric for the 60°F water temperature index value under the No-Action Alternative and Alternative 2 are 78 and 79 percent, respectively. The 1 percent difference in Minimum Percentage of Time Value between Alternative 2 and the No-Action Alternative represents a small increase in the number of habitat units with the smallest amount of time and area with water temperatures below 60°F under Alternative 2 compared to the No-Action Alternative.

The Maximum Percentage of Time Value metric presented in Table G-AQUA5.4-7 for the steelhead adult spawning and embryo incubation and holding did not change between Alternative 2 and the No-Action Alternative for the 57°F and 60°F water temperature index values. The Maximum Percentage of Time Value metric for the 52°F water temperature index value under the No-Action Alternative and Alternative 2 are 75 percent and 74 percent, respectively. The 1 percent difference in Maximum Percentage of Time Value between the No-Action Alternative and Alternative 2 represents a small decrease in the number of habitat units with the greatest amount of time and area with water temperatures below 52°F under Alternative 2 compared to the No-Action Alternative. The Maximum Percentage of Time Value metric for the 54°F water temperature index value under the No-Action Alternative and Alternative 2 are 90 percent and 91 percent, respectively. The 1 percent difference in Maximum Percentage of Time Value between Alternative 2 and the No-Action Alternative represents a small increase in the number of habitat units with the greatest amount of time and area with water temperatures below 54°F under Alternative 2 compared to the No-Action Alternative.

The Habitat Units at 100 Percent of Time metric presented in Table G-AQUA5.4-7 for the steelhead adult spawning and embryo incubation life stage did not change between Alternative 2 and the No-Action Alternative for the 52°F, 54°F, and 57°F water temperature index values. The Habitat Units at 100 Percent of Time for the 60°F water temperature index value under the No-Action Alternative and Alternative 2 are 11,890 and 21,526, respectively. The difference in Habitat Units at 100 Percent of Time between Alternative 2 and the No-Action Alternative is 9,636, which represents approximately an 81 percent increase in the amount of habitat area under Alternative 2 compared to the No-Action Alternative in which water temperatures are always at or below 60°F.

An 81.04 percent increase in the number of habitat units in which water temperatures are always at or below 60°F and above 57°F represents an increase in habitat under Alternative 2 in which specific biological effects could potentially occur to spawning adult

steelhead and steelhead incubating embryos, such as decreased fertilization rates, decreased adult survival, and substantially increased egg and embryo mortality (Kamler and Kato 1983; Kwain 1975; Velsen 1987).

The Percentage of Time at Maximum Habitat Units metric presented in Table G-AQUA5.4-7 for the steelhead adult spawning and embryo incubation life stage did not change between Alternative 2 and the No-Action Alternative for the 52°F and 54°F water temperature index values. The Percentage of Time at Maximum Habitat Units metric presented for the steelhead adult spawning and embryo incubation life stage for the 57°F water temperature index value under the No-Action Alternative and Alternative 2 are 72 percent and 73 percent, respectively. The difference in Percentage of Time at Maximum Habitat Units between Alternative 2 the No-Action Alternative is 1 percent, which represents an increase in the percentage of time that the habitat is suitable in the greatest area under Alternative 2. The Percentage of Time at Maximum Habitat Units metric presented for the steelhead adult spawning and embryo incubation life stage for the 60°F water temperature index value under the No-Action Alternative and Alternative 2 are 82 percent and 100 percent, respectively. The difference in Percentage of Time at Maximum Habitat Units between Alternative 2 the No-Action Alternative is 18 percent, which represents an increase in the percentage of time that the habitat is suitable in the greatest area under Alternative 2.

Fry and Fingerling Rearing and Downstream Movement

Figures G-AQUA5.4-32, G-AQUA5.4-33, G-AQUA5.4-34, and G-AQUA5.4-35 show the proportion of time that habitat units are considered suitable for each water temperature index value selected. The area under each curve displayed in Figures G-AQUA5.4-32, G-AQUA5.4-33, G-AQUA5.4-34, and G-AQUA5.4-35 is equal, which allows for direct comparison of habitat suitability between alternatives.

The OHSIV metrics presented in Table G-AQUA5.4-8 for steelhead fry and fingerling rearing and downstream movement for the 65°F water temperature index value under the No-Action Alternative and Alternative 2 are 2,083,223 and 2,107,073, respectively. The difference in OHSIV between Alternative 2 and the No-Action Alternative is 23,850, which represents a 1.14 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative. The OHSIV for the 68°F water temperature index value under the No-Action Alternative and Alternative 2 are 2,440,326 and 2,458,476, respectively. The difference in OHSIV between Alternative 2 and the No-Action Alternative is 18,150, which represents a 0.74 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative. The OHSIV for the 72°F water temperature index value under the No-Action Alternative and Alternative 2 are 2,786,096 and 2,794,411, respectively. The difference in OHSIV between Alternative 2 and the No-Action Alternative is 8,315, which represents a 0.30 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative. The OHSIV for the 75°F water temperature index value under the No-Action Alternative and Alternative 2 are 2,893,527 and 2,894,827, respectively. The difference in OHSIV between Alternative 2 and the No-Action Alternative is 1,289, which represents a 0.04 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative.

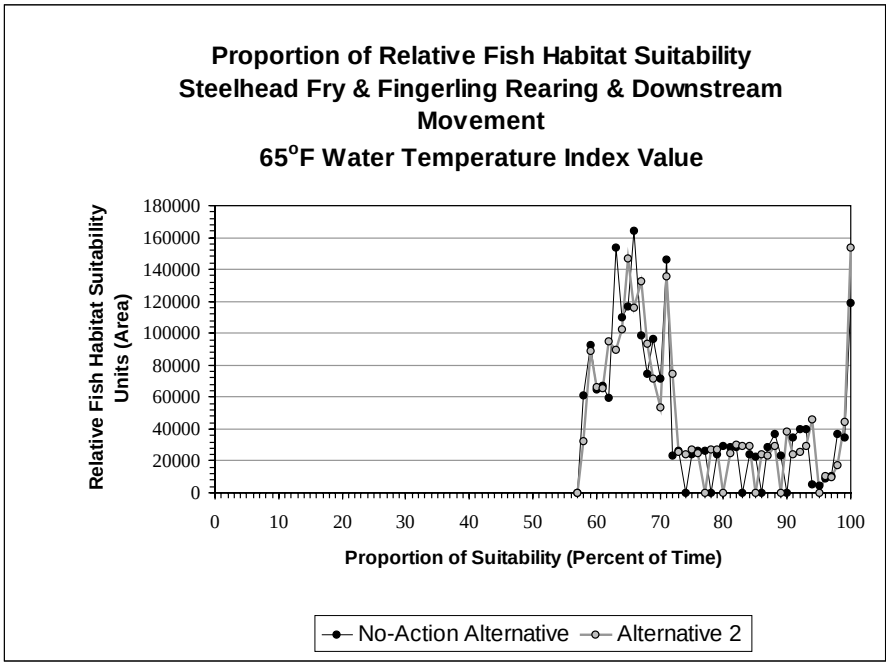

Figure G-AQUA5.4-32. Proportion of relative fish habitat suitability for steelhead fry and fingerling rearing and downstream movement for the 65°F water temperature index value.

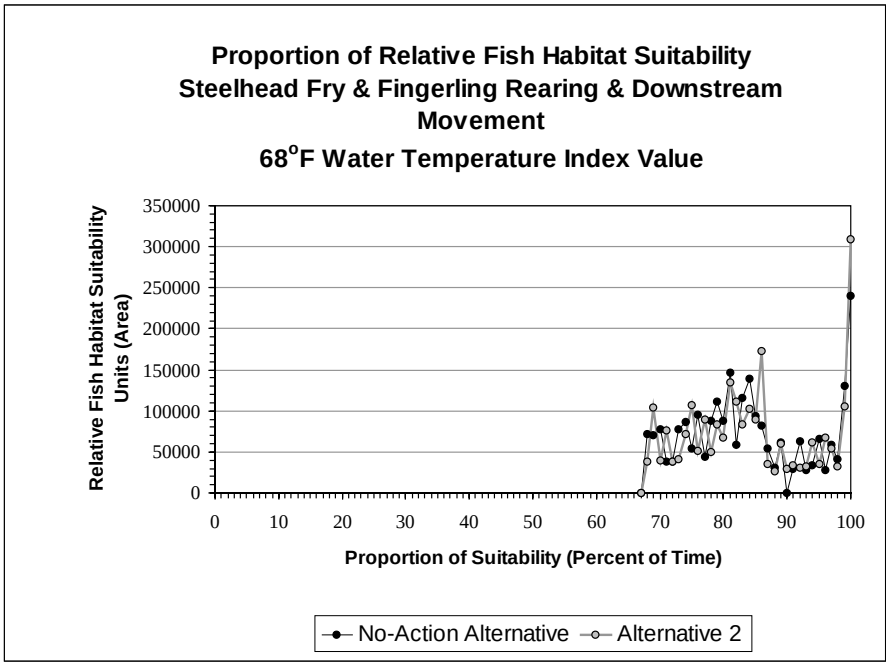

Figure G-AQUA5.4-33. Proportion of relative fish habitat suitability for steelhead fry and fingerling rearing and downstream movement for the 68°F water temperature index value.

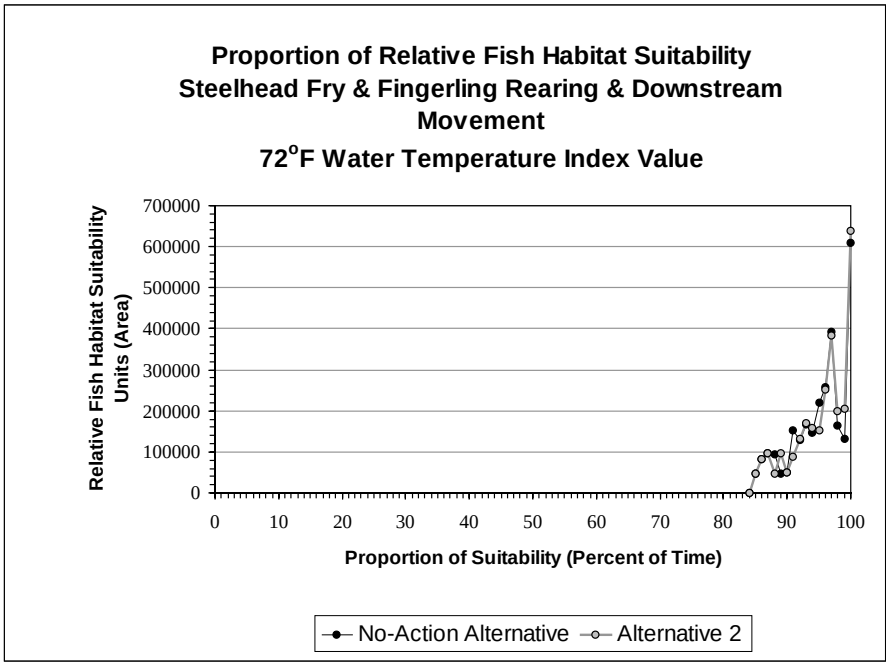

Figure G-AQUA5.4-34. Proportion of relative fish habitat suitability for steelhead fry and fingerling rearing and downstream movement for the 72°F water temperature index value.

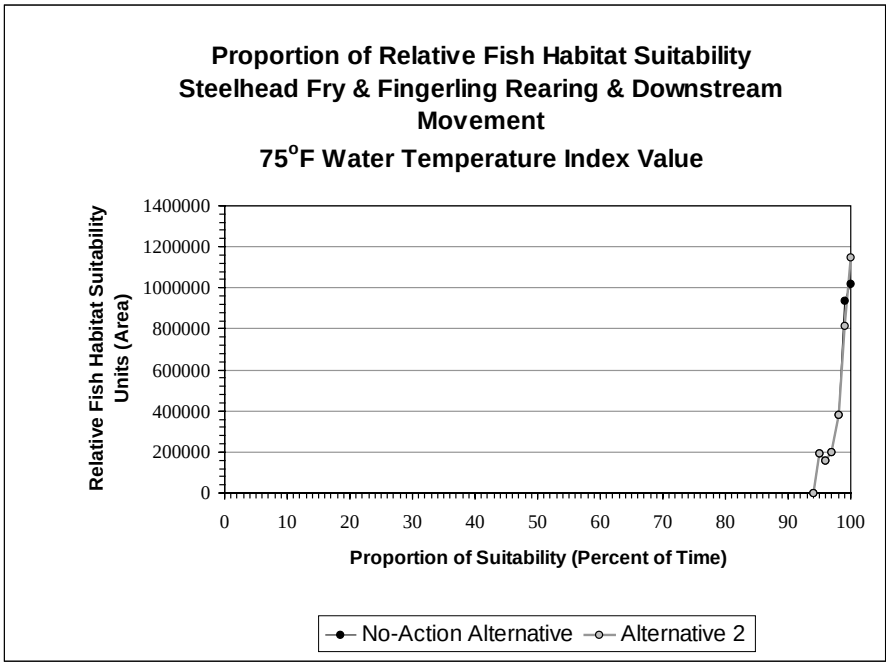

Figure G-AQUA5.4-35. Proportion of relative fish habitat suitability for steelhead fry and fingerling rearing and downstream movement for the 75°F water temperature index value.

Table G-AQUA5.4-8. Overall habitat suitability index value comparison the No-Action Alternative and Alternative 2 for steelhead fry and fingerling juvenile rearing and downstream movement.

Water Temperature Index Value	65°F	68°F	72°F	75°F
No-Action Alternative				
Minimum Percentage of Time Value	58%	68%	85%	95%
Maximum Percentage of Time Value	100%	100%	100%	100%
Habitat Units at 100 Percent of Time	119,042	240,338	609,003	1,020,829
Percentage of Time at Maximum Habitat Units	66%	100%	100%	100%
OHSIV	2,083,223	2,440,326	2,786,096	2,893,537
Alternative 2				
Minimum Percentage of Time Value	58%	68%	85%	95%
Maximum Percentage of Time Value	100%	100%	100%	100%
Habitat Units at 100 Percent of Time	153,953	308,266	639,613	1,149,758
Percentage of Time at Maximum Habitat Units	100%	100%	100%	100%
OHSIV	2,107,073	2,458,476	2,794,411	2,894,827
Percent Change	1.14%	0.74%	0.30%	0.04%

The Minimum Percentage of Time Value metric presented in Table G-AQUA5.4-8 for the steelhead fry and fingerling rearing and downstream movement life stage did not change between Alternative 2 and the No-Action Alternative for any of the water temperature index values selected.

The Maximum Percentage of Time Value metric presented in Table G-AQUA5.4-8 for the steelhead fry and fingerling rearing and downstream movement life stage did not change between Alternative 2 and the No-Action Alternative for any of the water temperature index values selected.

The Habitat Units at 100 Percent of Time metric presented in Table G-AQUA5.4-8 for the 65°F water temperature index value for the steelhead fry and fingerling rearing and downstream movement life stage under the No-Action Alternative and Alternative 2 are 119,042 and 153,953, respectively. The difference in Habitat Units at 100 Percent of Time between Alternative 2 and the No-Action Alternative is 34,911, which represents approximately a 29 percent increase in the amount of habitat area under Alternative 2 compared to the No-Action Alternative in which water temperatures are always at or below 65°F. The Habitat Units at 100 Percent of Time for the 68°F water temperature index value under the No-Action Alternative and Alternative 2 are 240,338 and 308,266, respectively. The difference in Habitat Units at 100 Percent of Time between Alternative 2 and the No-Action Alternative is 67,928, which represents approximately a 28 percent increase in the amount of habitat area under Alternative 2 compared to the No-Action Alternative in which water temperatures are always at or below 68°F. The Habitat Units at 100 Percent of Time for the 72°F water temperature index value under the No-Action Alternative and Alternative 2 are 609,003 and 639,613, respectively. The difference in Habitat Units at 100 Percent of Time between Alternative 2 and the No-Action Alternative is 30,610, which represents approximately a 5 percent increase in the

amount of habitat area under Alternative 2 compared to the No-Action Alternative in which water temperatures are always at or below 72°F. The Habitat Units at 100 Percent of Time for the 75°F water temperature index value under the No-Action Alternative and Alternative 2 are 1,020,829 and 1,149,758, respectively. The difference in Habitat Units at 100 Percent of Time between Alternative 2 and the No-Action Alternative is 128,929, which represents approximately a 13 percent increase in the amount of habitat area under Alternative 2 compared to the No-Action Alternative in which water temperatures are always at or below 75°F.

A 29 percent increase in the number of habitat units in which water temperatures are always at or below 65°F represents an increase in habitat under Alternative 2 that rearing and emigrating juvenile steelhead are reported to prefer (Cech and Myrick 1999; Cherry et al. 1977; Kaya et al. 1977). An 28 percent increase in the number of habitat units in which water temperatures are always at or below 68°F and above 65°F represents an increase in habitat under Alternative 2 that rearing and emigrating juvenile steelhead are reported to prefer (Cech and Myrick 1999; Cherry et al. 1977; Kaya et al. 1977). A 5 percent increase in the number of habitat units in which water temperatures are always at or below 72°F and above 68°F represents an increase in habitat under Alternative 2 in which specific biological effects could potentially occur to rearing and downstream migrating steelhead fry and fingerlings, such as increased physiological stress, increased agonistic activity, and a decrease in forage activity (Nielsen et al. 1994). A 13 percent increase in the number of habitat units in which water temperatures are always at or below 75°F and above 72°F represents an increase in habitat under Alternative 2 in which specific biological effects could potentially occur to rearing and downstream migrating steelhead fry and fingerlings, including increased physiological stress, decreased forage activity, and increased mortality (Nielsen et al. 1994; NOAA Fisheries 2001). A detailed description of the potential effects that could occur to rearing and downstream migrating fry and fingerlings steelhead from exposure to water temperatures between above each water temperature index value is presented in Section G-AQUA2.2.3 of Appendix G-AQUA2.

The Percentage of Time at Maximum Habitat Units metric presented in Table G-AQUA5.4-8 for the steelhead fry and fingerling rearing and downstream movement life stage did not change between Alternative 2 and the No-Action Alternative for the 68°F, 70°F, and 72°F water temperature index values. The Percentage of Time at Maximum Habitat Units presented for the steelhead fry and fingerling rearing and downstream movement life stage for the 65°F water temperature index value under the No-Action Alternative and Alternative 2 are 66 percent and 100 percent, respectively. The difference in Percentage of Time at Maximum Habitat Units between Alternative 2 and the No-Action Alternative is 34 percent, which represents an increase in the percentage of time that the habitat is suitable in the greatest area.

Smolt Emigration

Figures G-AQUA5.4-36 and G-AQUA5.4-37 show the proportion of time that habitat units are considered suitable for each water temperature index value selected. The

area under each curve displayed in Figures G-AQUA5.4-36 and G-AQUA5.4-37 is equal, which allows for direct comparison of habitat suitability between alternatives.

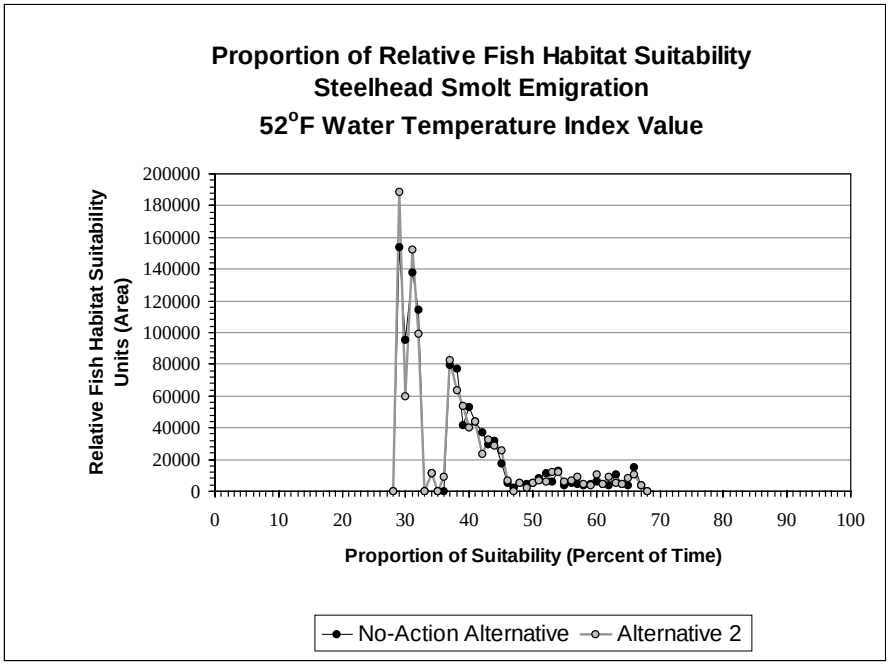

Figure G-AQUA5.4-36. Proportion of relative fish habitat suitability for steelhead smolt emigration for the 52°F water temperature index value.

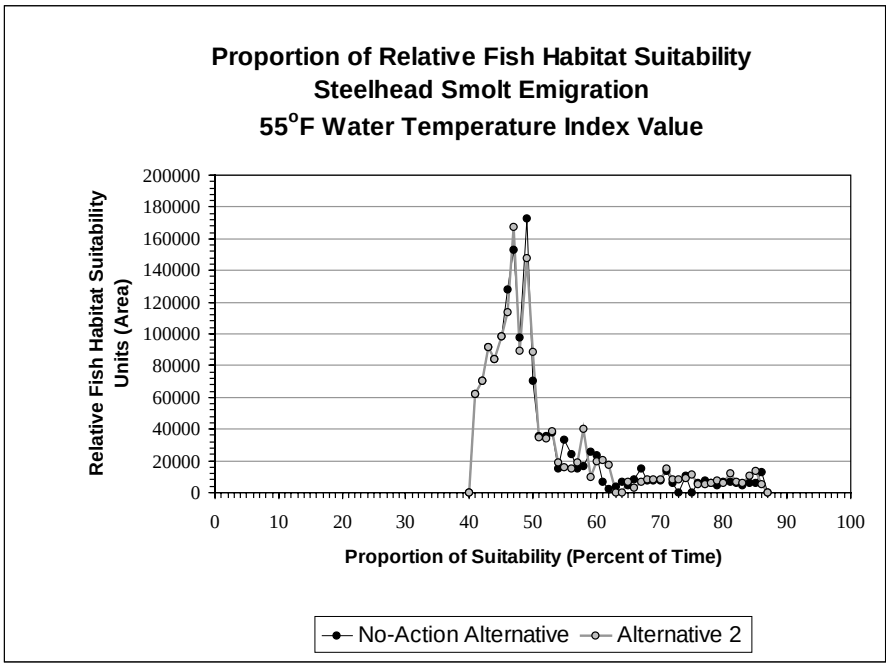

Figure G-AQUA5.4-37. Proportion of relative fish habitat suitability for steelhead smolt emigration for the 55°F water temperature index value.

The OHSIV metrics presented in Table G-AQUA5.4-9 for steelhead smolt emigration for the 52°F water temperature index value under the No-Action Alternative and Alternative 2 are 1,059,104 and 1,059,855, respectively. The difference in OHSIV between Alternative 2 and the No-Action Alternative is 751, which represents a 0.07 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative. The OHSIV for the 55°F water temperature index value under existing conditions and the No-Action Alternative are 1,463,377 and 1,475,677, respectively. The difference in OHSIV between Alternative 2 and the No-Action Alternative is 12,300, which represents a 0.84 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative.

Table G-AQUA5.4-9. Overall habitat suitability index value comparison between the No-Action Alternative and Alternative 2 for steelhead smolt emigration.

Water Temperature Index Value	**52°F**	**55°F**
No-Action Alternative		
Minimum Percentage of Time Value	29%	41%
Maximum Percentage of Time Value	67%	86%
Habitat Units at 100 Percent of Time	0	0
Percentage of Time at Maximum Habitat Units	29%	49%
OHSIV	1,059,104	1,463,377
Alternative 2		
Minimum Percentage of Time Value	29%	41%
Maximum Percentage of Time Value	67%	86%
Habitat Units at 100 Percent of Time	0	0
Percentage of Time at Maximum Habitat Units	29%	47%
OHSIV	1,059,855	1,475,677
Percent Change	0.07%	0.84%

The Minimum Percentage of Time Value metric presented in Table G-AQUA5.4-9 for the steelhead smolt emigration life stage did not change between Alternative 2 and the No-Action Alternative for any of the water temperature index values selected.

The Maximum Percentage of Time Value metric presented in Table G-AQUA5.4-9 for the steelhead smolt emigration life stage did not change between Alternative 2 and the No-Action Alternative for any of the water temperature index values selected.

The Habitat Units at 100 Percent of Time metric presented in Table G-AQUA5.4-9 for the steelhead smolt emigration life stage did not change between Alternative 2 and the No-Action Alternative for any of the water temperature index values selected.

The Percentage of Time at Maximum Habitat Units metric presented in Table G-AQUA5.4-9 for the steelhead smolt emigration life stage did not change between Alternative 2 and the No-Action Alternative for the 52°F water temperature index value. The Percentage of Time at Maximum Habitat Units metric for the steelhead smolt emigration life stage for the 55°F water temperature index value under the No-Action

Alternative and Alternative 2 are 49 percent and 47 percent, respectively. The difference in Percentage of Time at Maximum Habitat Units between the No-Action Alternative and Alternative 2 is two percent, which represents a small decrease in the percentage of time that the habitat is suitable in the greatest area.

G-AQUA5.4.3.3 Predation-related Effects

Changes in minimum flows in the Low Flow Channel with implementation of Alternative 2 are not expected to change the nature or rate of predation relative to the No-Action Alternative. Water temperature changes would be very small and are not expected to change the distribution, species composition, consumption rates, or nature of predation in the lower Feather River. Adaptive management changes in steelhead hatchery release practices may reduce predation of juvenile spring-run Chinook salmon. The Large Woody Debris Supplementation and Improvement Program would improve juvenile rearing cover conditions, resulting in a reduction of predation rates on juvenile steelhead.

G-AQUA5.4.3.4 Fisheries Management–related Effects

Hatchery

The Hatchery Adaptive Management Program included in Alternative 2 is the same as that included in the Proposed Action, with the exception of the inclusion of a water treatment facility for the hatchery water supply. (See Section G-AQUA4.4 of Appendix G-AQUA4, Effects of the Proposed Action, for an evaluation of the Hatchery Adaptive Management Program.) The proposed hatchery water treatment could reduce the rate of incidence and severity of disease occurrences in the Feather River Fish Hatchery, which, as a result, would lower contributions of accumulated disease pressure in the lower Feather River.

Disease

Water temperature changes with implementation of Alternative 2 would be relatively small; therefore, no changes in water temperature–related interactions with the incidence of fish diseases are anticipated. The proposed hatchery water treatment could reduce the rate of incidence and severity of disease occurrences in the Feather River Fish Hatchery, which, as a result, would lower contributions of the accumulated disease pressure in the lower Feather River.

Fishing Regulations, Poaching, and Change in Recreational Access and Visitation

Section 5.10.2, Recreation Resources Environmental Effects, forecasts a one-third increase in recreation and angling activities under the No-Action Alternative and an approximately 51 percent increase in recreation and angling under Alternative 2, as compared to the existing condition. This would indicate an expected increase of approximately 18 percent in recreation and angling under Alternative 2 relative to the No-Action Alternative. A 18 percent increase in angling, with no other PM&E measures related to fisheries, would equate to increased angler harvest rates. Fishing access

would be increased under Alternative 2 with the implementation of several recreation facilities on the lower Feather River. (See Section 5.10.2.3 for additional information on recreation facilities and changes in visitation under Alternative 2.) No fishing zones in proximity to the fish barrier weirs would require changes to fishing regulations under Alternative 2.

G-AQUA5.4.3.5 Summary of Potential Effects on Steelhead

Study plan report summaries addressing project effects on steelhead are presented in Section G-AQUA1.5, Fisheries Management; Section G-AQUA1.8, Salmonids and Their Habitat in the Feather River Below the Fish Barrier Dam; Section G-AQUA5.10, Instream Flows and Fish Habitat; and Section G-AQUA1.11, Predation, of Appendix G-AQUA1, Affected Environment. A description of each steelhead life stage and the time period associated with it is presented in Appendix G-AQUA1.

Effects on steelhead associated with installation of fish barrier weirs, the Large Woody Debris Supplementation and Improvement Program, and the Gravel Supplementation and Improvement Program with implementation of Alternative 2 would not differ from those effects associated with the Proposed Action; the proposed PM&E measures are the same under Alternative 2 and the Proposed Action as under the No-Action Alternative. Appendix G-AQUA4, Effects of the Proposed Action, describes the effects associated with each PM&E measure proposed for implementation under the Proposed Action. Additionally, water temperature–related effects resulting from changes in flows in the Low Flow Channel under Alternative 2 are not expected to alter disease or predation effects because the changes in water temperature compared to the No-Action Alternative would be small.

Adult Immigration and Holding

Actions potentially affecting steelhead adult immigration and holding include changes to instream flows and water temperatures in the Low Flow Channel. Creation and enhancement of side-channel habitat, and a Hatchery Adaptive Management Program, implemented under Alternative 2 would differ slightly from those PM&E measures proposed for implementation under the Proposed Action, but would have the same effects on steelhead adult immigration and holding compared to the No-Action Alternative. Appendix G-AQUA4, Effects of the Proposed Action, describes the effects associated with each PM&E measure proposed for implementation under the Proposed Action.

An increased instream flow of 800 cfs in the Low Flow Channel under Alternative 2 could potentially have a beneficial effect on immigrating and holding steelhead by increasing lower Feather River stage elevations. Although stage increases would be small, shallow riffles could potentially become deeper, reducing the effort required by immigrating adult steelhead to proceed through shallow riffles. Additional areas of the river would become suitable holding habitat as a result of increased water depths. Reduced average daily water temperatures during the steelhead adult immigration and holding period result in increased overall habitat suitability for the 56°F water

temperature index value. However, model results indicate that differences in habitat suitability due to decreased water temperatures for the remaining water temperature index values are less than 1 percent between the No-Action Alternative and Alternative 2, and as such, are considered below the detection limits of the analytical tools utilized in the habitat suitability analysis.

Overall, implementation of Alternative 2 would result in a slight beneficial effect on steelhead adult immigration and holding.

Adult Spawning and Embryo Incubation

Actions potentially affecting steelhead adult spawning and embryo incubation include a Hatchery Adaptive Management Program, creation and enhancement of side-channel habitat, and changes to instream flows and water temperatures in the Low Flow Channel. Many of the effects of a Hatchery Adaptive Management Program would be the same as those identified for the Proposed Action (Appendix G-AQUA4), relative to the No-Action Alternative, with one exception. The water treatment program associated with the Hatchery Adaptive Management Program under Alternative 2 would potentially have an additional beneficial effect on incubating steelhead embryos by reducing accumulated disease pressure in the lower Feather River.

Creation and enhancement of side-channel habitat under Alternative 2 would result in additional quantity and quality of side-channel habitat.

An increase in instream flow in the Low Flow Channel from 600 cfs to 800 cfs during the adult spawning and embryo incubation period would decrease PHABSIM steelhead spawning WUA from 98 percent of maximum to approximately 91 percent of maximum. Potential fluctuations in flow in the Low Flow Channel from May 1 through June 15 would not affect steelhead adult spawning and embryo incubation. Steelhead spawning in the lower Feather River ceases prior to May 1; therefore, no redd dewatering events would occur. Additionally, during extreme drought years, decreases in flow from 800 cfs to 750 cfs likely would have a beneficial effect on steelhead adult spawning and embryo incubation because 750 cfs represents approximately 93 percent of maximum WUA, while 800 cfs represents approximately 91 percent of maximum WUA. Reduced average daily water temperatures during the steelhead adult spawning and embryo incubation period result in increased overall habitat suitability for the 54°F, 57°F, and 60°F water temperature index values. However, model results indicate that differences in habitat suitability due to decreased water temperatures for the 52°F water temperature index value was less than 1 percent between the No-Action Alternative and Alternative 2, and as such, is considered below the detection limits of the analytical tools utilized in the habitat suitability analysis.

Overall, implementation of Alternative 2 would result in a beneficial effect on steelhead adult spawning and embryo incubation.

Juvenile Rearing and Downstream Movement

Actions potentially affecting rearing and downstream movement by steelhead fry and fingerlings include a Hatchery Adaptive Management Program, side-channel habitat enhancement and creation, and changes to instream flows and water temperatures in the Low Flow Channel. Many of the effects of a Hatchery Adaptive Management Program would be the same as those identified for the Proposed Action (Appendix G-AQUA4), relative to the No-Action Alternative, with one exception. The water treatment program associated with the Hatchery Adaptive Management Program under Alternative 2 would potentially have an additional beneficial effect on rearing fry and fingerling steelhead by reducing accumulated disease pressure in the lower Feather River.

Creation and enhancement of side-channel habitat under Alternative 2 would result in additional quantity and quality of side-channel habitat.

Flow fluctuations in the Low Flow Channel from 800 to 1,200 cfs could occur from May 1 through June 15, which could result in an adverse effect on steelhead fry and fingerling rearing and downstream movement by increasing the potential for beach stranding. Reduced average daily water temperatures during the steelhead adult spawning and embryo incubation period result in increased overall habitat suitability for the 65°F water temperature index value. However, model results indicate that differences in habitat suitability due to decreased water temperatures for the remaining water temperature index values were less than 1 percent between the No-Action Alternative and Alternative 2, and as such, are considered below the detection limits of the analytical tools utilized in the habitat suitability analysis.

Overall, implementation of Alternative 2 would result in a beneficial effect on steelhead juvenile rearing and downstream movement.

Smolt Emigration

Actions potentially affecting steelhead smolt emigration include a Hatchery Adaptive Management Program, and changes in instream flows and water temperatures in the Low Flow Channel. Many of the effects of a Hatchery Adaptive Management Program would be the same as identified for the Proposed Action (Appendix G-AQUA4), relative to the No-Action Alternative, with one exception. The water treatment program associated with the Hatchery Adaptive Management Program under Alternative 2 would potentially have an additional beneficial effect on emigrating steelhead smolts by reducing the accumulated disease pressure in the lower Feather River.

Model results indicate that differences in habitat suitability due to decreased water temperatures during the steelhead smolt emigration period were less than 1 percent between the No-Action Alternative and Alternative 2, and as such, are considered below the detection limits of the analytical tools utilized in the habitat suitability analysis. Therefore, water temperature changes in the Low Flow Channel due to increased flows would have no effect on steelhead smolt emigration.

Overall, implementation of Alternative 2 would result in a slight beneficial effect on steelhead smolt emigration.

Conclusion

Under Alternative 2, flows and flow fluctuations occurring in the High Flow Channel are not expected to differ from those occurring under the No-Action Alternative (described in Section 5.4.2.1, Water Quantity Environmental Effects). Therefore, Alternative 2 would not result in a flow-related change in the quality, quantity, or distribution of steelhead habitat occurring in the High Flow Channel. Flow increases in the Low Flow Channel and water temperature reductions also benefit the steelhead habitat quality and quantity. Habitat improvement programs including side-channel creation and enhancement and the Gravel Supplementation and Improvement Program and Large Woody Debris Supplementation and Improvement Program also would be beneficial for steelhead habitat quality and quantity.

Based on the above summary of potential effects, it is likely that implementation of Alternative 2 would result in an overall beneficial effect on steelhead.

G-AQUA5.4.4 American Shad

G-AQUA5.4.4.1 Flow-related Effects

American shad adult immigration occurs in May and June, and spawning occurs in June and July. American shad have been frequently observed in the Feather River from the Thermalito Afterbay Outlet downstream to the confluence with the Sacramento River. American shad are observed only infrequently upstream of the Thermalito Afterbay Outlet to Steep Riffle at River Mile (RM) 61. No changes in flow regimes downstream of the Thermalito Afterbay Outlet are included under Alternative 2, relative to the No-Action Alternative. Under Alternative 2, minimum flows in the river reach extending from the Fish Barrier Dam downstream to the Thermalito Afterbay Outlet would be increased from 600 to 800 cfs. Because American shad are observed only infrequently upstream of the Thermalito Afterbay Outlet, an increase in flow in this reach of the river is not anticipated to have any effect on American shad immigration or spawning.

G-AQUA5.4.4.2 Water Temperature–related Effects

Figure G-AQUA5.4-38 shows the proportion of time that habitat units are considered suitable for the water temperature range selected. The area under each curve displayed in Figure G-AQUA5.4-38 is equal, which allows for direct comparison of habitat suitability between alternatives. Figure G-AQUA5.4-38 shows the proportion of time during which habitat is suitable as defined by the water temperature range of 46°F to 79°F. Figures depicting the amount of habitat with water temperatures below 46°F or above 79°F were not included because changes in the proportion of time and area defined as suitable rather than changes in the proportion of time and area defined as unsuitable determines the effects of Alternative 2 on American shad adult immigration and spawning.

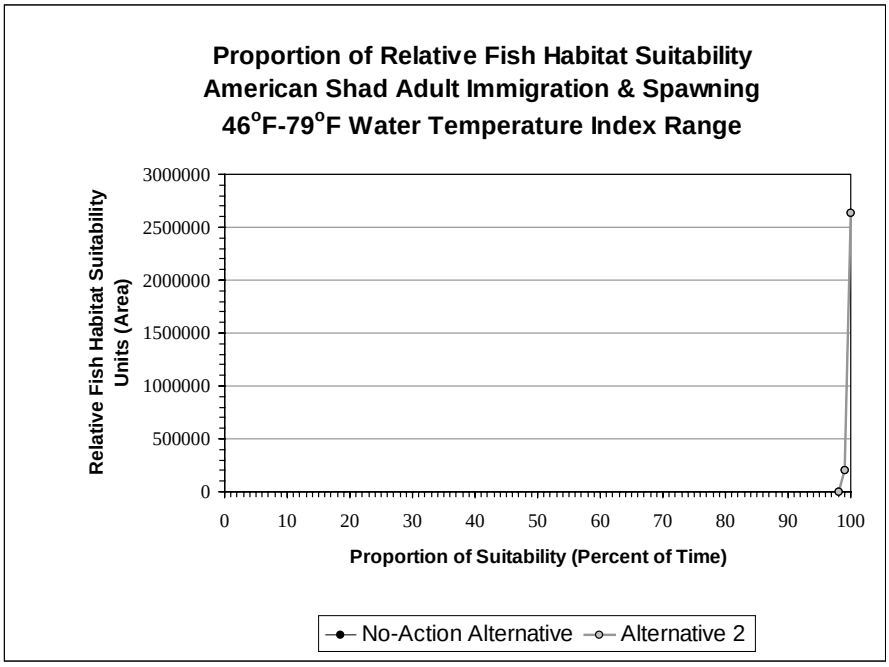

Figure G-AQUA5.4-38. Proportion of relative fish habitat suitability for American shad adult immigration and spawning for the 46°F to 79°F water temperature range.

The OHSIV presented in Table G-AQUA5.4-10 for American shad adult immigration and spawning for the 46°F to 79°F water temperature range under the No-Action Alternative and Alternative 2 are 2,836,030 and 2,836,030, respectively. The difference in OHSIV between Alternative 2 and the No-Action Alternative is 0, which represents a no change in OHSIV between Alternative 2 and the No-Action Alternative. Because analysis of the 46°F to 79°F water temperature range represents habitat that is suitable for the species and life stage based on available literature, the lack of change in OHSIV for this water temperature range represents no change in relative habitat suitability for American shad adult immigration and spawning in the lower Feather River between the No-Action Alternative and Alternative 2.

The Minimum Percentage of Time Value metric presented in Table G-AQUA5.4-10 for the American shad adult immigration and spawning life stage did not change between Alternative 2 and the No-Action Alternative for the 46°F to 79°F water temperature range.

The Maximum Percentage of Time Value metric presented in Table G-AQUA5.4-10 for the American shad adult immigration and spawning life stage did not change between Alternative 2 and the No-Action Alternative for the 46°F to 79°F water temperature range.

The Habitat Units at 100 Percent of Time metric presented in Table G-AQUA5.4-10 for the American shad adult immigration and spawning life stage did not change between Alternative 2 and the No-Action Alternative for the 46°F to 79°F water temperature range.

Table G-AQUA5.4-10. Overall habitat suitability index value comparison between the No-Action Alternative and Alternative 2 for American shad adult immigration and spawning.

Water Temperature Index Value	46°F-79°F
No-Action Alternative	
Minimum Percentage of Time Value	99%
Maximum Percentage of Time Value	100%
Habitat Units at 100 Percent of Time	2,631,869
Percentage of Time at Maximum Habitat Units	100%
OHSIV	2,836,030
Alternative 2	
Minimum Percentage of Time Value	99%
Maximum Percentage of Time Value	100%
Habitat Units at 100 Percent of Time	2,631,869
Percentage of Time at Maximum Habitat Units	100%
OHSIV	2,836,030
Percent Change	**0.00%**

The Percentage of Time at Maximum Habitat Units metric presented in Table G-AQUA5.4-10 for the American shad adult immigration and spawning life stage did not change between Alternative 2 and the No-Action Alternative for the 46°F to 79°F water temperature range.

G-AQUA5.4.4.3 Summary of Potential Effects on American Shad

Study plan report summaries addressing project effects on American shad are presented in Section G-AQUA1.4, Non-Salmonid Fish in the Feather River Downstream of the Thermalito Diversion Dam, of Appendix G-AQUA1.

Implementation of Alternative 2 would increase flows and slightly decrease water temperatures in the Low Flow Channel compared to the No-Action Alternative. However, because American shad are observed infrequently in the Low Flow Channel, an increase in flow would not have an effect on American shad adult immigration and spawning. Model results indicate that differences in habitat suitability due to decreased water temperatures during the American shad spawning period were less than 1 percent between the No-Action Alternative and Alternative 2, and as such, are considered below the detection limits of the analytical tools utilized in the habitat suitability analysis. Therefore, water temperature changes in the Low Flow Channel due to increased flows would have no effect on American shad adult spawning. Additionally, there would be no changes in flows or water temperatures in the High Flow Channel under Alternative 2. Therefore, no water temperature or flow-related effects on American shad would occur.

Based on the above summary of potential effects, it is likely that implementation of Alternative 2 would result in no effect on American shad.

G-AQUA5.4.5 Black Bass

G-AQUA5.4.5.1 Water Temperature–related Effects

Figure G-AQUA5.4-39 shows the proportion of time that habitat units are considered suitable for the water temperature range selected. The area under each curve displayed in Figure G-AQUA5.4-39 is equal, which allows for direct comparison of habitat suitability between alternatives. Figure G-AQUA5.4-39 shows the proportion of time during which habitat is suitable as defined by the water temperature range of 54°F to 75°F. Figures depicting the amount of habitat with water temperatures below 54°F or above 75°F were not included because changes in the proportion of time and area defined as suitable rather than changes in the proportion of time and area defined as unsuitable determines the effects of Alternative 2 on black bass adult spawning.

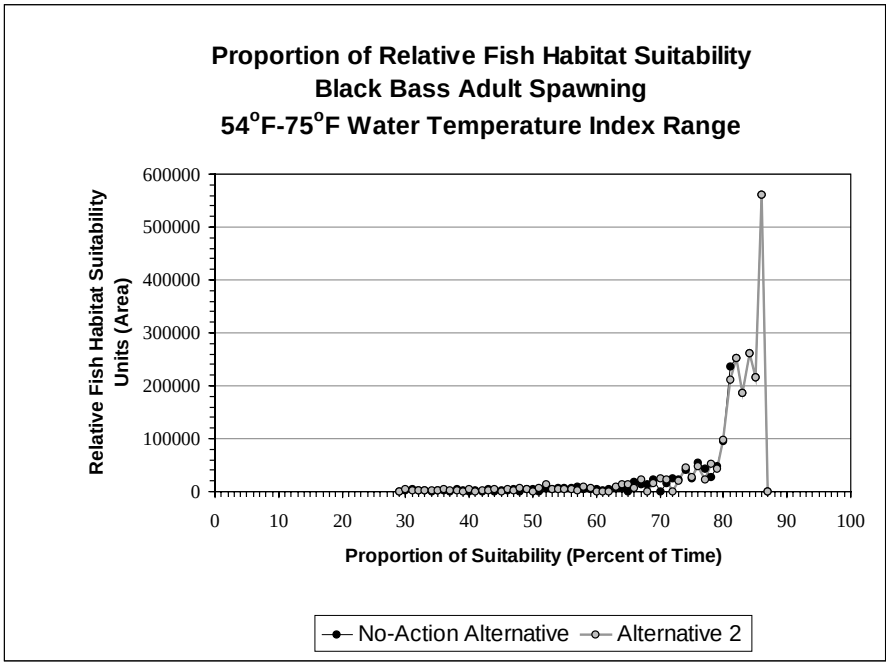

Figure G-AQUA5.4-39. Proportion of relative fish habitat suitability for black bass adult spawning for the 54°F to 75°F water temperature range.

The OHSIV presented in Table G-AQUA5.4-11 for black bass adult spawning for the 54°F to 75°F water temperature range under the No-Action Alternative and Alternative 2 are 2,300,520 and 2,287,189, respectively. The difference in OHSIV between the No-Action Alternative and Alternative 2 is 13,331, which represents a 0.58 percent decrease in OHSIV under Alternative 2 compared to the No-Action Alternative. Because analysis of the 54°F to 75°F water temperature range represents habitat that is suitable for the species and life stage based on available literature, the 0.58 percent decrease in OHSIV for this water temperature range represents a decrease in relative habitat suitability for black bass adult spawning in the lower Feather River. The decrease in relative habitat suitability under Alternative 2 is due to an increase in time and area with water temperatures cooler than the reported thermal tolerance range for black bass adult spawning during certain portions of the life stage period. The increase

in the number of habitat units below the reported thermal tolerance range for black bass adult spawning could result in more habitat defined as unsuitable and in which increased stress response could occur. The decrease in relative habitat suitability under Alternative 2 also is associated with an increase in time and area with water temperatures above the reported thermal tolerance range for black bass adult spawning during certain portions of the life stage period. The decrease in relative habitat suitability due to water temperatures outside the reported thermal tolerance range of this species and life stage generally could result in more habitat in which increased stress response including raised or lowered metabolic rates, decreased spawning activity, decreased growth rates, and potentially increased mortality rates could occur (Bond 1996; Moyle 2002; Moyle and Cech 2000).

Table G-AQUA5.4-11. Overall habitat suitability index value comparison between the No-Action Alternative and Alternative 2 for black bass adult spawning.

Water Temperature Index Value	54°F-75°F
No-Action Alternative	
Minimum Percentage of Time Value	30%
Maximum Percentage of Time Value	86%
Habitat Units at 100 Percent of Time	0
Percentage of Time at Maximum Habitat Units	86%
OHSIV	2,300,520
Alternative 2	
Minimum Percentage of Time Value	30%
Maximum Percentage of Time Value	86%
Habitat Units at 100 Percent of Time	0
Percentage of Time at Maximum Habitat Units	86%
OHSIV	2,287,189
Percent Change	-0.58%

The Minimum Percentage of Time Value metric presented in Table G-AQUA5.4-11 for the black bass adult spawning life stage did not change between Alternative 2 and the No-Action Alternative for the 54°F to 75°F water temperature range.

The Maximum Percentage of Time Value metric presented in Table G-AQUA5.4-11 for the black bass adult spawning life stage did not change between Alternative 2 and the No-Action Alternative for the 54°F to 75°F water temperature range.

The Habitat Units at 100 Percent of Time metric presented in Table G-AQUA5.4-11 for the black bass adult spawning life stage did not change between Alternative 2 and the No-Action Alternative for the 54°F to 75°F water temperature range.

The Percentage of Time at Maximum Habitat Units metric presented in Table G-AQUA5.4-11 for the black bass adult spawning life stage did not change between Alternative 2 and the No-Action Alternative for the 54°F to 75°F water temperature range.

G-AQUA5.4.5.2 Summary of Potential Effects on Black Bass

Study plan report summaries addressing project effects on black bass species are presented in Section G-AQUA1.3, Fish and Their Habitat within Lake Oroville, its Upstream Tributaries, the Thermalito Complex, and the Oroville Wildlife Area; Section G-AQUA1.4, Non-Salmonid Fish in the Feather River Downstream of the Thermalito Diversion Dam; Section G-AQUA1.5, Fisheries Management, and Section G-AQUA1.11, Predation, of Appendix G-AQUA1, Affected Environment.

Implementation of Alternative 2 would increase flows and decrease water temperatures in the Low Flow Channel compared to the No-Action Alternative. Model results indicate that differences in habitat suitability due to decreased water temperatures during the black bass spawning period were less than 1 percent between the No-Action Alternative and Alternative 2, and as such, are considered below the detection limits of the analytical tools utilized in the habitat suitability analysis. Therefore, water temperature changes in the Low Flow Channel due to increased flows would have no effect on black bass adult spawning. No changes to flows or water temperatures would occur in the High Flow Channel under Alternative 2.

Overall, implementation of Alternative 2 would have no effect on black bass.

G-AQUA5.4.6 Delta Smelt

G-AQUA5.4.6.1 Habitat Components

Adult Spawning

Delta smelt spawn in the upper Sacramento–San Joaquin Delta (Delta) upstream of the mixing zone and use a range of substrates for spawning, including reeds and other submerged vegetation, sandy or hard substrates, and submerged wood. The Large Woody Debris Supplementation and Improvement Program for the lower Feather River included in Alternative 2 is expected to contribute large woody debris to the Delta and provide improvements in habitat diversity and spawning substrate availability, benefiting delta smelt.

G-AQUA5.4.6.2 Summary of Potential Effects on Delta Smelt

Study plan report summaries addressing project effects on delta smelt are presented in Section G-AQUA1.4, Non-Salmonid Fish in the Feather River Downstream of the Thermalito Diversion Dam, of Appendix G-AQUA1.

The range of distribution of the delta smelt is outside of the direct and indirect effects area analyzed for changes in flows and temperatures associated with the Oroville Facilities, therefore no flow or water temperature effects on delta smelt are anticipated with implementation of Alternative 2. Delta smelt would benefit from implementation of Alternative 2 as a result of the Large Woody Debris Supplementation and Improvement Program for the lower Feather River because habitat diversity and spawning habitat quantity in the upper Delta areas would increase. Large woody debris supplementation

under Alternative 2 would have the same effects on delta smelt spawning as implementation of the Proposed Action, relative to the No-Action Alternative.

G-AQUA5.4.7 Green Sturgeon

G-AQUA5.4.7.1 Flow-related Effects

Flows in the portions of the lower Feather River where sturgeon are distributed would not change with implementation of Alternative 2 relative to the No-Action Alternative; therefore, there would be no flow-related effects on green sturgeon under Alternative 2. Structural modifications of Shanghai Bench and the Sunset Pumps for sturgeon passage enhancement are related to conditions resulting from flows and are included in Alternative 2 (see Section 3.3 for an additional description of this action). During the reporting process for SP-F3.2, Task 3A, two potential sturgeon passage impediments were identified that may block or inhibit upstream migration of sturgeon at some low flows. (See Section G-AQUA1.4.3 of Appendix G-AQUA1 for a summary of the report.) Although there is some lack of certainty as to the benefit of structurally modifying these potential sturgeon passage impediments, it is likely that these structural modifications would increase the range of flows associated with these features, which would provide improved passage for sturgeon.

G-AQUA5.4.7.2 Water Temperature-related Effects

Adult Immigration and Holding

Figure G-AQUA5.4-40 shows the proportion of time that habitat units are considered suitable for the water temperature range selected. The area under each curve displayed in Figure G-AQUA5.4-40 is equal, which allows for direct comparison of habitat suitability between alternatives. Figure G-AQUA5.4-40 shows the proportion of time during which habitat is suitable as defined by the water temperature range of 44°F to 61°F. Figures depicting the amount of habitat with water temperatures below 44°F or above 61°F were not included because changes in the proportion of time and area defined as suitable rather than changes in the proportion of time and area defined as unsuitable determines the effects of Alternative 2 on green sturgeon adult immigration and holding.

The OHSIV presented in Table G-AQUA5.4-12 for green sturgeon adult immigration and holding for the 44°F to 61°F water temperature range under the No-Action Alternative and Alternative 2 are 1,657,011 and 1,683,379, respectively. The difference in OHSIV between Alternative 2 and the No-Action Alternative is 26,368, which represents a 1.59 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative. Because analysis of the 44°F to 61°F water temperature range represents habitat that is suitable for the species and life stage based on available literature, the 1.59 percent increase in OHSIV for this water temperature range represents an increase in relative habitat suitability for green sturgeon adult immigration and holding in the lower Feather River. The increase in overall habitat suitability for green sturgeon adult immigration and holding would result in more habitat defined as

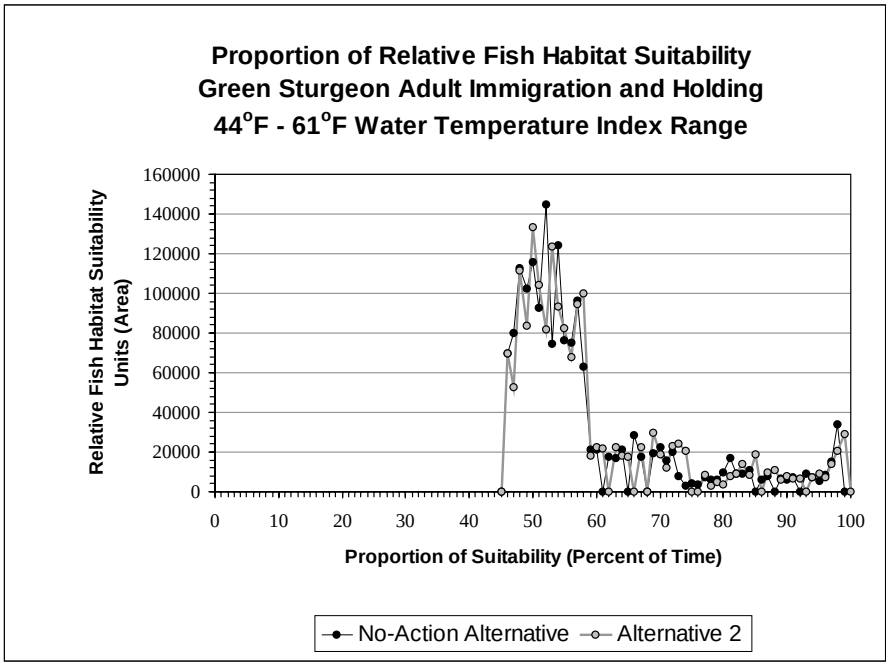

Figure G-AQUA5.4-40. Proportion of relative fish habitat suitability for green sturgeon adult immigration and holding for the 44°F to 61°F water temperature range.

Table G-AQUA5.4-12. Overall habitat suitability index value comparison between the No-Action Alternative and Alternative 2 for green sturgeon adult immigration and holding.

Water Temperature Index Value	44°F-61°F
No-Action Alternative	
Minimum Percentage of Time Value	46%
Maximum Percentage of Time Value	98%
Habitat Units at 100 Percent of Time	0
Percentage of Time at Maximum Habitat Units	52%
OHSIV	1,657,011
Alternative 2	
Minimum Percentage of Time Value	46%
Maximum Percentage of Time Value	99%
Habitat Units at 100 Percent of Time	0
Percentage of Time at Maximum Habitat Units	50%
OHSIV	1,683,379
Percent Change	1.59%

suitable and less habitat in which increased stress response including raised metabolic rates, decreased growth rates, and increased mortality rates could potentially occur (Bond 1996; Moyle 2002; Moyle and Cech 2000).

The Minimum Percentage of Time Value metric presented in Table G-AQUA5.4-12 for the green sturgeon adult immigration and holding life stage did not change between Alternative 2 and the No-Action Alternative for the 44°F to 61°F water temperature range.

The Maximum Percentage of Time Value metric presented in Table G-AQUA5.4-12 for the green sturgeon adult immigration and holding life stage under the No-Action Alternative and Alternative 2 for the 44°F to 61°F water temperature range is 98 percent and 99 percent, respectively. The 1 percent difference between Alternative 2 and the No-Action Alternative represents a small increase in the number of habitat units with the greatest amount of time and area with water temperatures in the 44°F to 61°F water temperature range under Alternative 2 compared to the No-Action Alternative.

The Habitat Units at 100 Percent of Time metric presented in Table G-AQUA5.4-12 for the green sturgeon adult immigration and holding life stage did not change between the No-Action Alternative and Alternative 2 for the 44°F to 61°F water temperature range.

The Percentage of Time at Maximum Habitat Units metric presented in Table G-AQUA5.4-12 for the green sturgeon adult immigration and holding life stage under the No-Action Alternative and Alternative 2 for the 44°F to 61°F water temperature range is 52 percent and 50 percent, respectively. The difference in Percentage of Time at Maximum Habitat Units between the No-Action Alternative and Alternative 2 is two percent, which represents a small decrease in the percentage of time that the habitat is suitable in the greatest area.

Adult Spawning and Embryo Incubation

Figure G-AQUA5.4-41 shows the proportion of time that habitat units are considered suitable for the water temperature range selected. The area under each curve displayed in Figure G-AQUA5.4-41 is equal, which allows for direct comparison of habitat suitability between alternatives. Figure G-AQUA5.4-41 shows the proportion of time during which habitat is suitable as defined by the water temperature range of 46°F to 68°F. Figures depicting the amount of habitat with water temperatures below 46°F or above 68°F were not included because changes in the proportion of time and area defined as suitable rather than changes in the proportion of time and area defined as unsuitable determines the effects of Alternative 2 on green sturgeon adult spawning and embryo incubation.

The OHSIV presented in Table G-AQUA5.4-13 for green sturgeon adult spawning and embryo incubation for the 46°F to 68°F water temperature range under the No-Action Alternative and Alternative 2 are 57,858 and 58,816, respectively. The difference in OHSIV between Alternative 2 and the No-Action Alternative is 958, which represents a

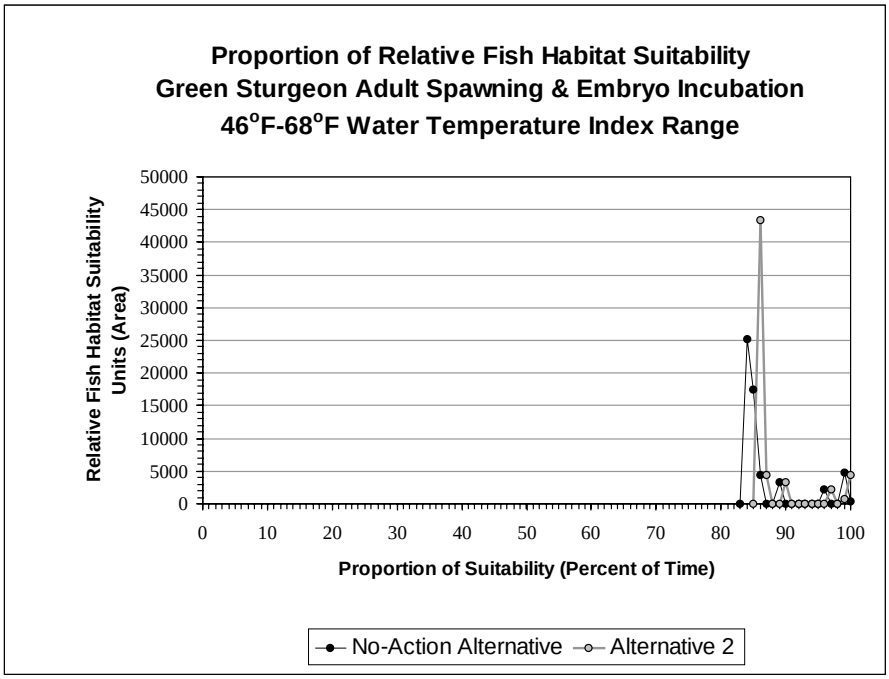

Figure G-AQUA5.4-41. Proportion of relative fish habitat suitability for green sturgeon adult spawning and embryo incubation for the 46°F to 68°F water temperature range.

Table G-AQUA5.4-13. Overall habitat suitability index value comparison between the No-Action Alternative and Alternative 2 for green sturgeon adult spawning and embryo incubation.

Water Temperature Index Value	46°F-68°F
No-Action Alternative	
Minimum Percentage of Time Value	84%
Maximum Percentage of Time Value	100%
Habitat Units at 100 Percent of Time	436
Percentage of Time at Maximum Habitat Units	84%
OHSIV	57,858
Alternative 2	
Minimum Percentage of Time Value	86%
Maximum Percentage of Time Value	100%
Habitat Units at 100 Percent of Time	4,472
Percentage of Time at Maximum Habitat Units	86%
OHSIV	58,816
Percent Change	1.66%

1.66 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative. Because analysis of the 46°F to 68°F water temperature range represents habitat that is suitable for the species and life stage based on available literature, the 1.66 percent increase in OHSIV for this water temperature range represents an increase in relative habitat suitability for green sturgeon adult spawning and embryo incubation in the lower Feather River. The increase in overall habitat suitability for green sturgeon adult spawning and embryo incubation would result in more habitat defined as suitable and less habitat in which increased stress response including raised metabolic rates, decreased spawning activity, decreased growth rates, and increased mortality rates could potentially occur (Bond 1996; Moyle 2002; Moyle and Cech 2000).

The Minimum Percentage of Time Value metric presented in Table G-AQUA5.413 for the green sturgeon adult spawning and embryo incubation life stage under the No-Action Alternative and Alternative 2 for the 46°F to 68°F water temperature range is 84 percent and 86 percent, respectively. The two percent difference between Alternative 2 and the No-Action Alternative represents a small increase in the number of habitat units with the least amount of time and area with water temperatures in the 46°F to 68°F water temperature range under Alternative 2 compared to the No-Action Alternative.

The Maximum Percentage of Time Value metric presented in Table G-AQUA5.4-13 for the green sturgeon adult spawning and embryo incubation life stage did not change between Alternative 2 and the No-Action Alternative for the 46°F to 68°F water temperature range.

The Habitat Units at 100 Percent of Time metric presented in Table G-AQUA5.4-13 for the green sturgeon adult spawning and embryo incubation life stage for the 46°F to 68°F water temperature range under the No-Action Alternative and Alternative 2 is 436 and 4,472, respectively. The difference in Habitat Units at 100 Percent of Time between Alternative 2 and the No-Action Alternative is 4,036, which represents approximately a 926 percent increase in the amount of habitat area under Alternative 2 compared to the No-Action Alternative in which water temperatures are between 46°F to 68°F.

The Percentage of Time at Maximum Habitat Units metric presented in Table G-AQUA5.4-13 for the green sturgeon adult spawning and embryo incubation life stage under the No-Action Alternative and Alternative 2 for the 46°F to 68°F water temperature range is 84 percent and 86 percent, respectively. The difference in Percentage of Time at Maximum Habitat Units between Alternative 2 and the No-Action Alternative is two percent, which represents a small increase in the percentage of time that the habitat is suitable in the greatest area.

Juvenile Rearing

Figure G-AQUA5.4-42 shows the proportion of time that habitat units are considered suitable for the water temperature range selected. The area under each curve displayed in Figure G-AQUA5.4-42 is equal, which allows for direct comparison of habitat suitability between alternatives. Figure G-AQUA5.4-42 shows the proportion of

time during which habitat is suitable as defined by the water temperature range of 50°F to 66°F. Figures depicting the amount of habitat with water temperatures below 50°F or above 66°F were not included because changes in the proportion of time and area defined as suitable rather than changes in the proportion of time and area defined as unsuitable determines the effects of Alternative 2 on green sturgeon juvenile rearing.

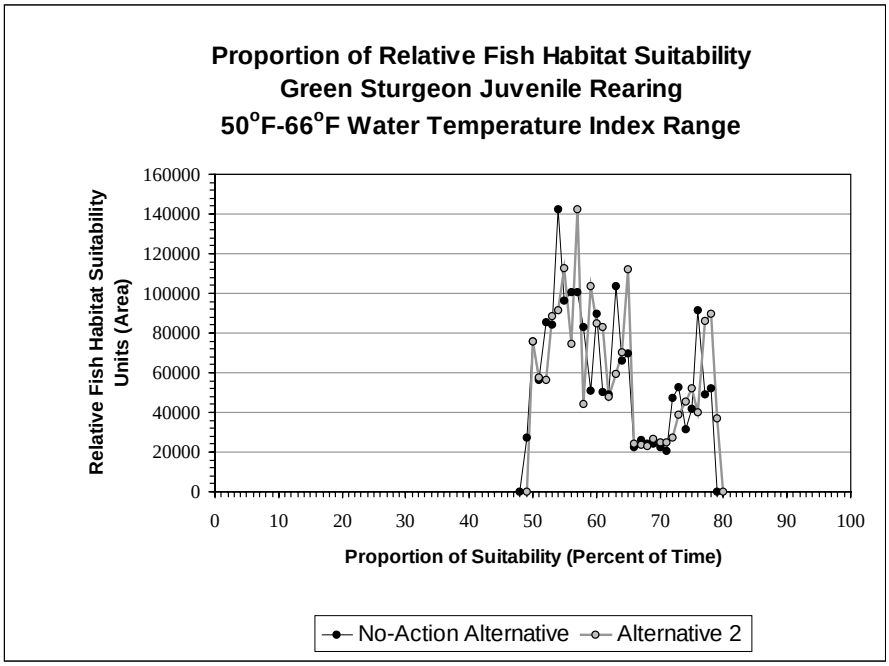

Figure G-AQUA5.4-42. Proportion of relative fish habitat suitability for green sturgeon juvenile rearing for the 50°F to 66°F water temperature range.

The OHSIV presented in Table G-AQUA5.4-14 for green sturgeon juvenile rearing for the 50°F to 66°F water temperature range under the No-Action Alternative and Alternative 2 are 1,837,131 and 1,868,184, respectively. The difference in OHSIV between Alternative 2 and the No-Action Alternative is 31,053, which represents a 1.69 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative. Because analysis of the 50°F to 66°F water temperature range represents habitat that is suitable for the species and life stage based on available literature, the 1.69 percent increase in OHSIV for this water temperature range represents an increase in relative habitat suitability for green sturgeon juvenile rearing in the lower Feather River. The increase in overall habitat suitability for green sturgeon juvenile rearing would result in more habitat defined as suitable and less habitat in which increased stress response including lowered or raised metabolic rates, decreased forage activity, decreased growth rates, and increased mortality rates could potentially occur (Bond 1996; Moyle 2002; Moyle and Cech 2000).

The Minimum Percentage of Time Value metric presented in Table G-AQUA5.4-14 for the green sturgeon juvenile rearing life stage under the No-Action Alternative and Alternative 2 for the 50°F to 66°F water temperature range is 49 percent and 50 percent, respectively. The 1 percent difference in Minimum Percentage of Time Value

Table G-AQUA5.4-14. Overall habitat suitability index value comparison between the No-Action Alternative and Alternative 2 for green sturgeon juvenile rearing.

Water Temperature Index Value	50°F-66°F
No-Action Alternative	
Minimum Percentage of Time Value	49%
Maximum Percentage of Time Value	78%
Habitat Units at 100 Percent of Time	0
Percentage of Time at Maximum Habitat Units	54%
OHSIV	1,837,131
Alternative 2	
Minimum Percentage of Time Value	50%
Maximum Percentage of Time Value	79%
Habitat Units at 100 Percent of Time	0
Percentage of Time at Maximum Habitat Units	57%
OHSIV	1,868,184
Percent Change	1.69%

between Alternative 2 and the No-Action Alternative represents a small increase in the number of habitat units with the smallest amount of time and area with water temperatures in the 50°F to 66°F water temperature range under Alternative 2 compared to the No-Action Alternative.

The Maximum Percentage of Time Value metric presented in Table G-AQUA5.4-14 for the green sturgeon juvenile rearing life stage under the No-Action Alternative and Alternative 2 for the 50°F to 66°F water temperature range is 78 percent and 79 percent, respectively. The 1 percent difference between Alternative 2 and the No-Action Alternative represents a small increase in the number of habitat units with the greatest amount of time and area with water temperatures in the 50°F to 66°F water temperature range under Alternative 2 compared to the No-Action Alternative.

The Habitat Units at 100 Percent of Time metric presented in Table G-AQUA5.4-14 for the green sturgeon juvenile rearing life stage did not change between Alternative 2 and the No-Action Alternative for the 50°F to 66°F water temperature range.

The Percentage of Time at Maximum Habitat Units metric presented in Table G-AQUA5.4-14 for the green sturgeon juvenile rearing life stage under the No-Action Alternative and Alternative 2 for the 50°F to 66°F water temperature range is 54 percent and 57 percent, respectively. The difference in Percentage of Time at Maximum Habitat Units between the No-Action Alternative and Alternative 2 is three percent, which represents an increase in the percentage of time that the habitat is suitable in the greatest area.

Juvenile Emigration

Figure G-AQUA5.4-43 shows the proportion of time that habitat units are considered suitable for the water temperature range selected. The area under each curve displayed in Figure G-AQUA5.4-43 is equal, which allows for direct comparison of habitat suitability between alternatives. Figure G-AQUA5.4-43 shows the proportion of time during which habitat is suitable as defined by the water temperature range of 50°F to 66°F. Figures depicting the amount of habitat with water temperatures below 50°F or above 66°F were not included because changes in the proportion of time and area defined as suitable rather than changes in the proportion of time and area defined as unsuitable determines the effects of Alternative 2 on green sturgeon juvenile emigration.

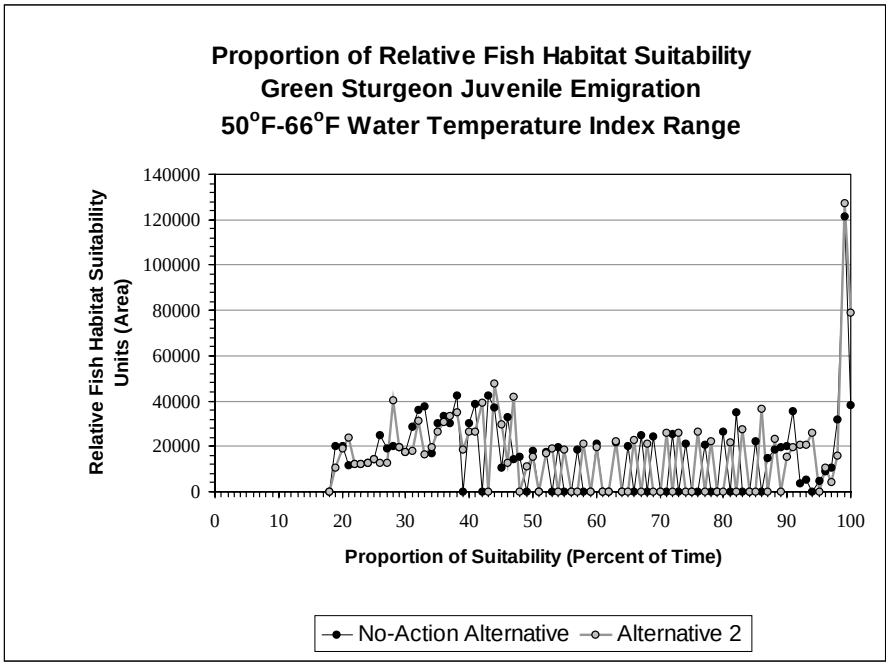

Figure G-AQUA5.4-43. Proportion of relative fish habitat suitability for green sturgeon juvenile emigration for the 50°F to 66°F water temperature range.

The OHSIV presented in Table G-AQUA5.4-15 for green sturgeon juvenile emigration for the 50°F to 66°F water temperature range under the No-Action Alternative and Alternative 2 are 1,354,092 and 1,398,150, respectively. The difference in OHSIV between Alternative 2 and the No-Action Alternative is 44,057, which represents a 3.25 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative. Because analysis of the 50°F to 66°F water temperature range represents habitat that is suitable for the species and life stage based on available literature, the 3.25 percent increase in OHSIV for this water temperature range represents an increase in relative habitat suitability for green sturgeon juvenile emigration in the lower Feather River. The increase in overall habitat suitability for green sturgeon juvenile rearing would result in more habitat defined as suitable and less habitat in which increased stress response including lowered or raised metabolic rates, decreased forage activity, decreased

growth rates, and increased mortality rates could potentially occur (Bond 1996; Moyle 2002; Moyle and Cech 2000).

Table G-AQUA5.4-15. Overall habitat suitability index value comparison between the No-Action Alternative and Alternative 2 for green sturgeon juvenile emigration.

Water Temperature Index Value	50°F-66°F
No-Action Alternative	
Minimum Percentage of Time Value	19%
Maximum Percentage of Time Value	100%
Habitat Units at 100 Percent of Time	37,977
Percentage of Time at Maximum Habitat Units	99%
OHSIV	1,354,092
Alternative 2	
Minimum Percentage of Time Value	19%
Maximum Percentage of Time Value	100%
Habitat Units at 100 Percent of Time	79,272
Percentage of Time at Maximum Habitat Units	99%
OHSIV	1,398,150
Percent Change	3.25%

The Minimum Percentage of Time Value metric presented in Table G-AQUA5.4-15 for the green sturgeon juvenile emigration life stage did not change between Alternative 2 and the No-Action Alternative for the 50°F to 66°F water temperature range.

The Maximum Percentage of Time Value metric presented in Table G-AQUA5.4-15 for the green sturgeon juvenile emigration life stage did not change between Alternative 2 and the No-Action Alternative for the 50°F to 66°F water temperature range.

The Habitat Units at 100 Percent of Time metric presented in Table G-AQUA5.4-15 for the green sturgeon juvenile emigration life stage under the No-Action Alternative and Alternative 2 for the 50°F to 66°F water temperature range is 37,977 and 79,272, respectively. The difference in Habitat Units at 100 Percent of Time between Alternative 2 and the No-Action Alternative is 41,295, which represents a 108.74 percent increase in the amount of habitat area under Alternative 2 compared to the No-Action Alternative in which water temperatures are always between 50°F and 66°F.

The Percentage of Time at Maximum Habitat Units metric presented in Table G-AQUA5.4-15 for the green sturgeon juvenile emigration life stage did not change between the No-Action Alternative and Alternative 2 for the 50°F to 66°F water temperature range.

G-AQUA5.4.7.2 Summary of Potential Effects on Green Sturgeon

Study plan report summaries addressing project effects on green sturgeon are presented in Section G-AQUA1.3, Fish and Their Habitat within Lake Oroville, its Upstream Tributaries, the Thermalito Complex, and the Oroville Wildlife Area; and Section G-AQUA1.4, Non-Salmonid Fish in the Feather River Downstream of the Thermalito Diversion Dam, of Appendix G-AQUA1.

Implementation of Alternative 2 would increase flows and decrease water temperatures in the Low Flow Channel relative to the No-Action Alternative. However, flows in the portions of the lower Feather River where sturgeon reportedly are distributed would not change with implementation of Alternative 2 relative to the No-Action Alternative. Therefore, there would be no flow-related effects on green sturgeon under Alternative 2. Based on model results, increases in overall habitat suitability for each life stage of green sturgeon due to improvements in water temperature would occur. Therefore, overall green sturgeon habitat suitability would increase under Alternative 2. Additionally, physical alterations to Shanghai Bench and the Sunset Pumps could potentially have a beneficial effect on green sturgeon by increasing the range of flows that are passable by sturgeon under Alternative 2.

Overall, implementation of Alternative 2 would have a beneficial effect on green sturgeon.

G-AQUA5.4.8 Hardhead

G-AQUA5.4.8.1 Temperature-related Effects

Spawning

Figure G-AQUA5.4-44 shows the proportion of time that habitat units are considered suitable for the water temperature range selected. The area under each curve displayed in Figure G-AQUA5.4-44 is equal, which allows for direct comparison of habitat suitability between alternatives. Figure G-AQUA5.4-44 shows the proportion of time during which habitat is suitable as defined by the water temperature range of 55°F to 75°F. Figures depicting the amount of habitat with water temperatures below 55°F or above 75°F were not included because changes in the proportion of time and area defined as suitable rather than changes in the proportion of time and area defined as unsuitable determine the effects of the Alternative 2 on hardhead adult spawning.

The OHSIV presented in Table G-AQUA5.4-16 for hardhead adult spawning for the 55°F to 75°F water temperature range under the No-Action Alternative and Alternative 2 are 2,769,601 and 2,759,676, respectively. The difference in OHSIV between the No-Action Alternative and Alternative 2 is 9,925, which represents a 0.36 percent decrease in OHSIV under Alternative 2 compared to the No-Action Alternative. Because analysis of the 55°F to 75°F water temperature range represents habitat that is suitable for the species and life stage based on available literature, the 0.36 percent decrease in

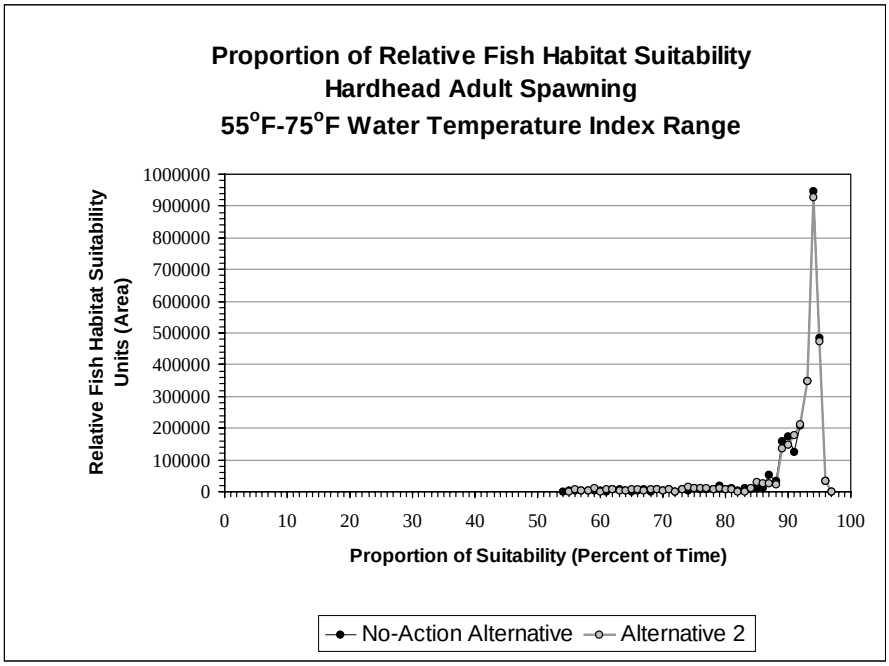

Figure G-AQUA5.4-44. Proportion of relative fish habitat suitability for hardhead adult spawning for the 55°F to 75°F water temperature range.

Table G-AQUA5.4-16. Overall habitat suitability index value comparison between the No-Action Alternative and Alternative 2 for hardhead adult spawning.

Water Temperature Index Value	55°F-75°F
No-Action Alternative	
Minimum Percentage of Time Value	55%
Maximum Percentage of Time Value	96%
Habitat Units at 100 Percent of Time	0
Percentage of Time at Maximum Habitat Units	94%
OHSIV	2,769,601
Alternative 2	
Minimum Percentage of Time Value	56%
Maximum Percentage of Time Value	96%
Habitat Units at 100 Percent of Time	0
Percentage of Time at Maximum Habitat Units	94%
OHSIV	2,759,676
Percent Change	-0.36%

OHSIV for this water temperature range represents a decrease in relative habitat suitability for hardhead adult spawning in the lower Feather River. The decrease in overall habitat suitability for hardhead adult spawning would result in less habitat defined as suitable and more habitat in which increased stress response including raised or lowered metabolic rates, decreased forage activity, decreased growth rates, and increased mortality rates could occur (Bond 1996; Moyle 2002; Moyle and Cech 2000).

The Minimum Percentage of Time Value metric presented in Table G-AQUA5.4-16 for the hardhead adult spawning life stage under the No-Action Alternative and Alternative 2 for the 55°F to 75°F water temperature range is 55 percent and 56 percent, respectively. The 1 percent difference between Alternative 2 and the No-Action Alternative represents a small increase in the number of habitat units with the least amount of time and area with water temperatures in the 55°F to 75°F water temperature range under Alternative 2 compared to the No-Action Alternative.

The Maximum Percentage of Time Value metric presented in Table G-AQUA5.4-16 for the hardhead adult spawning life stage did not change between Alternative 2 and the No-Action Alternative for the 55°F to 75°F water temperature.

The Habitat Units at 100 Percent of Time metric presented in Table G-AQUA5.4-16 for the hardhead adult spawning life stage did not change between Alternative 2 and the No-Action Alternative for the 55°F to 75°F water temperature range.

The Percentage of Time at Maximum Habitat Units metric presented in Table G-AQUA5.4-16 for the hardhead adult spawning life stage did not change between Alternative 2 and the No-Action Alternative for the 55°F to 75°F water temperature range.

G-AQUA5.4.8.2 Summary of Potential Effects on Hardhead

Study plan report summaries addressing project effects on hardhead are presented in Section G-AQUA1.4, Non-Salmonid Fish in the Feather River Downstream of the Thermalito Diversion Dam, of Appendix G-AQUA1.

Implementation of Alternative 2 would increase flows and decrease water temperatures in the Low Flow Channel, relative to the No-Action Alternative. However, there would be no changes to flows or water temperatures in the High Flow Channel under Alternative 2. Model results indicate that differences in habitat suitability due to decreased water temperatures during the hardhead spawning period were less than 1 percent between the No-Action Alternative and Alternative 2, and as such, are considered below the detection limits of the analytical tools utilized in the habitat suitability analysis. Therefore, water temperature changes in the Low Flow Channel due to increased flows would have no effect on hardhead spawning.

Overall, implementation of Alternative 2 would result in no effect on the hardhead.

G-AQUA5.4.9 River Lamprey

G-AQUA5.4.9.1 Temperature-related Effects

Spawning

Figure G-AQUA5.4-45 shows the proportion of time that habitat units are considered suitable for the water temperature range selected. The area under each curve displayed in Figure G-AQUA5.4-45 is equal, which allows for direct comparison of habitat suitability between alternatives. Figure G-AQUA5.4-45 shows the proportion of time during which habitat is suitable as defined by the water temperature range of 43°F to 72°F. Figures depicting the amount of habitat with water temperatures below 43°F or above 72°F were not included because changes in the proportion of time and area defined as suitable rather than changes in the proportion of time and area defined as unsuitable determines the effects of Alternative 2 on river lamprey adult spawning.

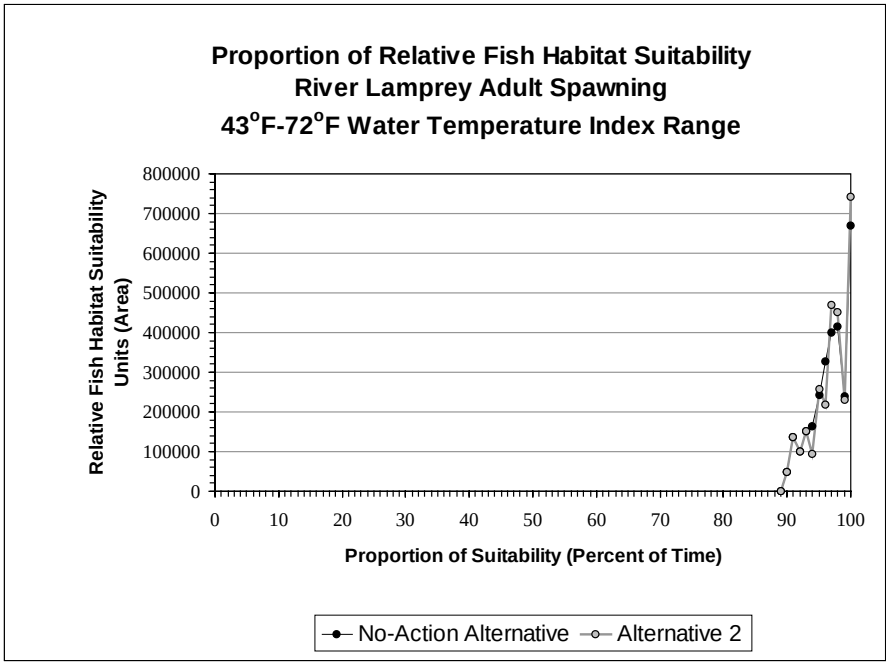

Figure G-AQUA5.4-45. Proportion of relative fish habitat suitability for river lamprey adult spawning for the 43°F to 72°F water temperature range.

The OHSIV presented in Table G-AQUA5.4-17 for river lamprey adult spawning for the 43°F to 72°F water temperature range under the No-Action Alternative and Alternative 2 are 2,899,309 and 2,904,637, respectively. The difference in OHSIV between Alternative 2 and the No-Action Alternative is 5,328, which represents a 0.18 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative. Because analysis of the 43°F to 72°F water temperature range represents habitat that is suitable for the species and life stage based on available literature, the 0.18 percent increase in OHSIV for this water temperature range represents an increase in relative habitat suitability for river lamprey adult spawning in the lower Feather River. The increase in overall habitat suitability for river lamprey adult spawning would result in more habitat

defined as suitable and less habitat in which increased stress response including increased metabolic rate, decreased growth rate, and potentially increased mortality (Bond 1996; Moyle 2002; Moyle and Cech 2000).

Table G-AQUA5.4-17. Overall habitat suitability index value comparison between the No-Action Alternative and Alternative 2 for river lamprey adult spawning.

Water Temperature Index Value	43°F-72°F
No-Action Alternative	
Minimum Percentage of Time Value	90%
Maximum Percentage of Time Value	100%
Habitat Units at 100 Percent of Time	670,928
Percentage of Time at Maximum Habitat Units	100%
OHSIV	2,899,309
Alternative 2	
Minimum Percentage of Time Value	90%
Maximum Percentage of Time Value	100%
Habitat Units at 100 Percent of Time	742,125
Percentage of Time at Maximum Habitat Units	100%
OHSIV	2,904,637
Percent Change	0.18%

The Minimum Percentage of Time Value metric presented in Table G-AQUA5.4-17 for the river lamprey adult spawning life stage did not change between Alternative 2 and the No-Action Alternative for the 43°F to 72°F water temperature range.

The Maximum Percentage of Time Value metric presented in Table G-AQUA5.4-17 for the river lamprey adult spawning life stage did not change between Alternative 2 and the No-Action Alternative for the 43°F to 72°F water temperature range.

The Habitat Units at 100 Percent of Time metric presented in Table G-AQUA5.4-17 for the river lamprey adult spawning life stage for the 43°F to 72°F water temperature range under the No-Action Alternative and Alternative 2 is 670,928 and 742,125, respectively. The difference in Habitat Units at 100 Percent of Time between Alternative 2 and the No-Action Alternative is 71,197, which represents approximately an 11 percent increase in the amount of habitat area under Alternative 2 compared to the No-Action Alternative in which water temperatures are between 43°F to 72°F.

The Percentage of Time at Maximum Habitat Units metric presented in Table G-AQUA5.4-17 for the river lamprey adult spawning life stage did not change between Alternative 2 and the No-Action Alternative for the 43°F to 72°F water temperature range.

G-AQUA5.4.9.2 Summary of Potential Effects on River Lamprey

Study plan report summaries addressing project effects on river lamprey are presented in Section G-AQUA1.4, Non-Salmonid Fish in the Feather River Downstream of the Thermalito Diversion Dam, of Appendix G-AQUA1

Implementation of Alternative 2 would increase flows and decrease water temperatures in the Low Flow Channel, relative to the No-Action Alternative. However, there would be no changes to flows or water temperatures in the High Flow Channel under Alternative 2. Model results indicate that differences in habitat suitability due to decreased water temperatures during the river lamprey spawning period were less than 1 percent between the No-Action Alternative and Alternative 2, and as such, are considered below the detection limits of the analytical tools utilized in the habitat suitability analysis. Therefore, water temperature changes in the Low Flow Channel due to increased flows would have no effect on river lamprey spawning. Additionally, river lamprey would benefit from improved spawning substrate conditions resulting from the Gravel Supplementation and Improvement Program.

Overall, implementation of Alternative 2 would result in a beneficial effect on the river lamprey.

G-AQUA5.4.10 Sacramento Splittail

G-AQUA5.4.10.1 Flow-related Effects

Spawning

Sacramento splittail have only been observed in the Feather River downstream of the Thermalito Afterbay Outlet. No changes in flow regimes are anticipated with implementation of Alternative 2 in this portion of the river; therefore, potential flow-related effects on Sacramento splittail spawning are not included for analysis.

G-AQUA5.4.10.2 Water Temperature–related Effects

Figure G-AQUA5.4-46 shows the proportion of time that habitat units are considered suitable for the water temperature range selected. The area under each curve displayed in Figure G-AQUA5.4-46 is equal, which allows for direct comparison of habitat suitability between alternatives. Figure G-AQUA5.4-46 shows the proportion of time during which habitat is suitable as defined by the water temperature range of 45°F to 75°F. Figures depicting the amount of habitat with water temperatures below 45°F or above 75°F were not included because changes in the proportion of time and area defined as suitable rather than changes in the proportion of time and area defined as unsuitable determines the effects of Alternative 2 on Sacramento splittail adult spawning.

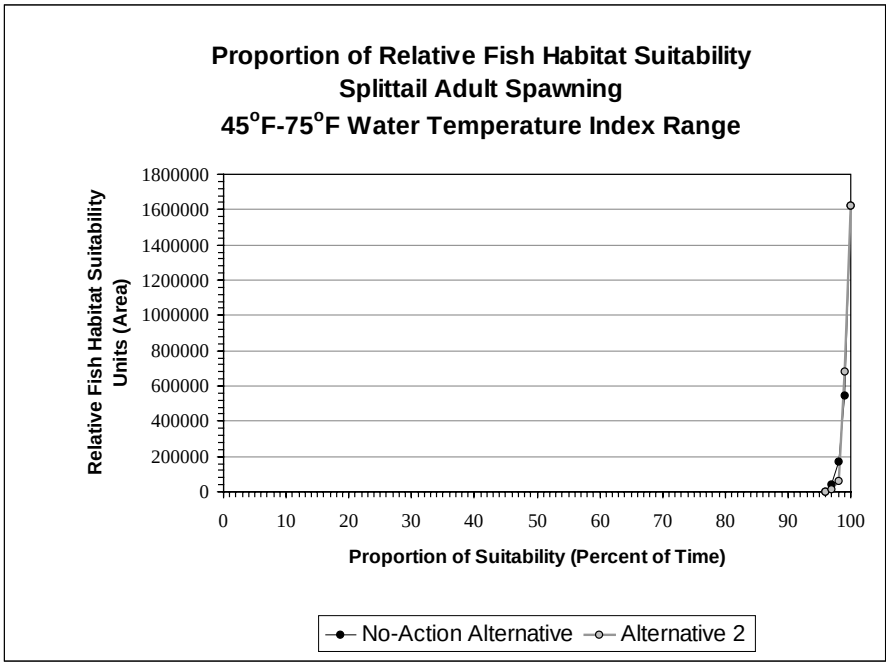

Figure G-AQUA5.4-46. Proportion of relative fish habitat suitability for Sacramento splittail adult spawning for the 45°F to 75°F water temperature range.

The OHSIV presented in Table G-AQUA5.4-18 for Sacramento splittail adult spawning for the 45°F to 75°F water temperature range under the No-Action Alternative and Alternative 2 are 2,375,091 and 2,376,769, respectively. The difference in OHSIV between Alternative 2 and the No-Action Alternative is 1,678, which represents a 0.07 percent increase in OHSIV under Alternative 2 compared to the No-Action Alternative. Because analysis of the 45°F to 75°F water temperature range represents habitat that is suitable for the species and life stage based on available literature, the 0.07 percent increase in OHSIV for this water temperature range represents an increase in relative habitat suitability for Sacramento splittail adult spawning in the lower Feather River. The increase in overall habitat suitability for river lamprey adult spawning would result in more habitat defined as suitable and less habitat in which increased stress response including increased metabolic rate, decreased growth rate, and potentially increased mortality (Bond 1996; Moyle 2002; Moyle and Cech 2000).

The Minimum Percentage of Time Value metric presented in Table G-AQUA5.4-18 for the Sacramento splittail adult spawning life stage did not change between Alternative 2 and the No-Action Alternative for the 45°F to 75°F water temperature range.

The Maximum Percentage of Time Value metric presented in Table G-AQUA5.4-18 for the Sacramento splittail adult spawning life stage did not change between Alternative 2 and the No-Action Alternative for the 45°F to 75°F water temperature range.

The Habitat Units at 100 Percent of Time metric presented in Table G-AQUA5.4-18 for the Sacramento splittail adult spawning life stage did not change between Alternative 2 and the No-Action Alternative for the 45°F to 75°F water temperature range.

Table G-AQUA5.4-18. Overall habitat suitability index value comparison between the No-Action Alternative and Alternative 2 for Sacramento splittail adult spawning.

Water Temperature Index Value	45°F-75°F
No-Action Alternative	
Minimum Percentage of Time Value	97%
Maximum Percentage of Time Value	100%
Habitat Units at 100 Percent of Time	1,623,725
Percentage of Time at Maximum Habitat Units	100%
OHSIV	2,375,091
Alternative 2	
Minimum Percentage of Time Value	97%
Maximum Percentage of Time Value	100%
Habitat Units at 100 Percent of Time	1,623,725
Percentage of Time at Maximum Habitat Units	100%
OHSIV	2,376,769
Percent Change	0.07%

The Percentage of Time at Maximum Habitat Units metric presented in Table G-AQUA5.4-18 for the Sacramento splittail adult spawning life stage did not change between Alternative 2 and the No-Action Alternative for the 45°F to 75°F water temperature range.

G-AQUA5.4.10.3 Summary of Potential Effects on Sacramento Splittail

Study plan report summaries addressing project effects on Sacramento splittail are presented in Section G-AQUA1.4, Non-Salmonid Fish in the Feather River Downstream of the Thermalito Diversion Dam, of Appendix G-AQUA1.

There would be no changes to flows or water temperatures in the High Flow Channel under Alternative 2. Because no such changes would occur and Sacramento splittail have only been observed in the High Flow Channel within the project study area, no flow–related effects on splittail spawning are expected to occur. Model results indicate that differences in habitat suitability due to decreased water temperatures during the river Sacramento splittail spawning period were less than 1 percent between the No-Action Alternative and Alternative 2, and as such, are considered below the detection limits of the analytical tools utilized in the habitat suitability analysis. Therefore, water temperature changes in the Low Flow Channel due to increased flows would have no effect on river lamprey spawning.

Overall, implementation of Alternative 2 is not anticipated to affect Sacramento splittail.

G-AQUA5.4.11 Striped Bass

G-AQUA5.4.11.1 Flow-related Effects

Adult Spawning

No changes in flows below the Thermalito Afterbay Outlet in the lower Feather River would result from implementation of Alternative 2; therefore, the majority of striped bass habitat would not be affected. Minimum flows in the river reach extending from the Fish Barrier Dam downstream to the Thermalito Afterbay Outlet would increase from 600 cfs to 800 cfs with implementation of Alternative 2. Because striped bass are only infrequently observed upstream of the Thermalito Afterbay Outlet, an increase in flow in this reach of the river is not anticipated to have any effect on the quantity, quality, or distribution of striped bass habitat.

G-AQUA5.4.11.2 Water Temperature–related Effects

Adult Spawning

Figure G-AQUA5.4-47 shows the proportion of time that habitat units are considered suitable for the water temperature range selected. The area under each curve displayed in Figure G-AQUA5.4-47 is equal, which allows for direct comparison of habitat suitability between alternatives. Figure G-AQUA5.4-47 shows the proportion of time during which habitat is suitable as defined by the water temperature range of 59°F to 68°F. Figures depicting the amount of habitat with water temperatures below 59°F or above 68°F were not included because changes in the proportion of time and area defined as suitable rather than changes in the proportion of time and area defined as unsuitable determines the effects of Alternative 2 on striped bass adult spawning.

The OHSIV presented in Table G-AQUA5.4-19 for striped bass adult spawning for the 59°F to 68°F water temperature range under the No-Action Alternative and Alternative 2 are 46,506 and 43,683, respectively. The difference in OHSIV between the No-Action Alternative and Alternative 2 is 2,822, which represents a 6.07 percent decrease in OHSIV under Alternative 2 compared to the No-Action Alternative. Because analysis of the 59°F to 68°F water temperature range represents habitat that is suitable for the species and life stage based on available literature, the 6.07 percent decrease in OHSIV for this water temperature range represents a decrease in relative habitat suitability for striped bass adult spawning in the lower Feather River. The decrease in overall habitat suitability for hardhead adult spawning would result in less habitat defined as suitable and more habitat in which increased stress response including raised or lowered metabolic rates, decreased forage activity, decreased growth rates, and increased mortality rates could occur (Bond 1996; Moyle 2002; Moyle and Cech 2000). Most of the decrease in striped bass adult spawning habitat suitability occurs in the Low Flow Channel where striped bass are infrequently observed.

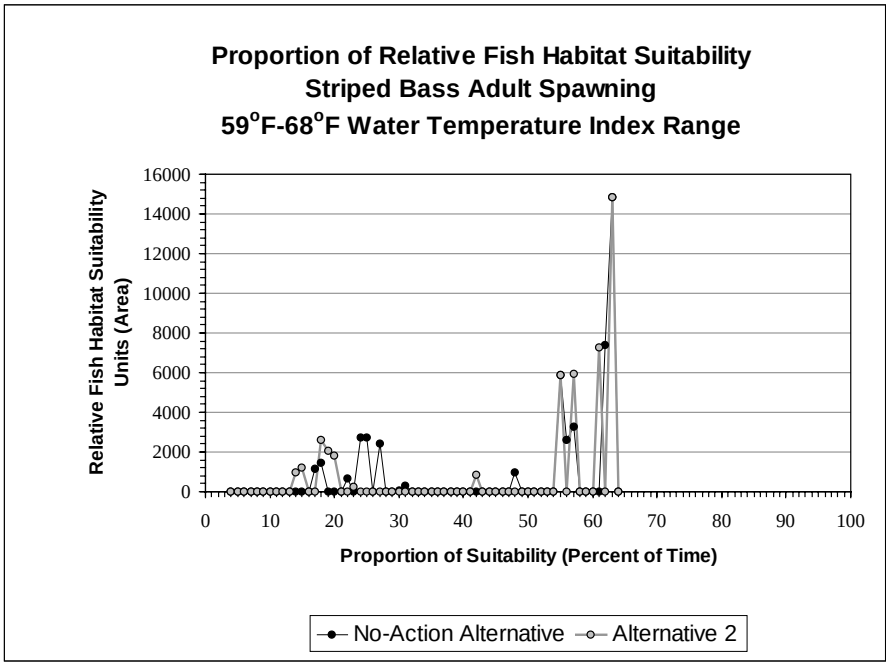

Figure G-AQUA5.4-47. Proportion of relative fish habitat suitability for striped bass adult spawning for the 59°F to 68°F water temperature range.

Table G-AQUA5.4-19. Overall habitat suitability index value comparison between the No-Action Alternative and Alternative 2 for striped bass adult spawning.

Water Temperature Index Value	59°F-68°F
No-Action Alternative	
Minimum Percentage of Time Value	5%
Maximum Percentage of Time Value	63%
Habitat Units at 100 Percent of Time	0
Percentage of Time at Maximum Habitat Units	63%
OHSIV	46,506
Alternative 2	
Minimum Percentage of Time Value	5%
Maximum Percentage of Time Value	63%
Habitat Units at 100 Percent of Time	0
Percentage of Time at Maximum Habitat Units	63%
OHSIV	43,683
Percent Change	-6.07%

The Minimum Percentage of Time Value metric presented in Table G-AQUA5.4-19 for the striped bass adult spawning life stage did not change between Alternative 2 and the No-Action Alternative for the 59°F to 68°F water temperature range.

The Maximum Percentage of Time Value metric presented in Table G-AQUA5.4-19 for the striped bass adult spawning life stage did not change between Alternative 2 and the No-Action Alternative for the 59°F to 68°F water temperature range.

The Habitat Units at 100 Percent of Time metric presented in Table G-AQUA5.4-19 for the striped bass adult spawning life stage did not change between Alternative 2 and the No-Action Alternative for the 59°F to 68°F water temperature range.

The Percentage of Time at Maximum Habitat Units metric presented in Table G-AQUA5.4-19 for the striped bass adult spawning life stage did not change between Alternative 2 and the No-Action Alternative for the 59°F to 68°F water temperature range.

G-AQUA5.4.11.3 Summary of Potential Effects on Striped Bass

Study plan report summaries addressing project effects on striped bass are presented in Section G-AQUA1.4, Non-Salmonid Fish in the Feather River Downstream of the Thermalito Diversion Dam, of Appendix G-AQUA1.

Implementation of Alternative 2 would increase flows and decrease water temperatures in the Low Flow Channel, relative to the No-Action Alternative. However, there would be no changes to flows in the High Flow Channel under Alternative 2. Because such changes would not occur and striped bass are frequently observed in the High Flow Channel, no flow-related effects on striped bass spawning habitat would occur within most of the areas where striped bass are observed. Because striped bass are only infrequently observed in the Low Flow Channel, reduced water temperatures are not likely to substantially affect striped bass spawning.

Overall, implementation of Alternative 2 would not be expected to have any effect on the quantity, quality, or distribution of striped bass habitat.

G-AQUA5.5 REFERENCES

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